CHIROPRACTIC ORTHOPEDY

DONALD O. PHARAOH

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THIS BOOK IS MOST
AFFECTIONATELY DEDICATED
TO MY WIFE

PREFACE

This book is intended primarily to give students a basic understanding of the spinal column, in health and in disease. It can also be of use to practicing chiropractors as a means of review or enlightenment as they encounter various orthopedic conditions in their work.

I have endeavored to present an easily read account of the spinal column in as much detail as seems required for a thorough knowledge of the subject. The unusual and the rare have been omitted for the reason that they would but confuse and obscure the important material. Such rarities would be better considered in a companion volume. It is hoped that the subject matter will create a desire on the part of the student to pursue the study of Chiropractic Orthopedy more extensively in the years to come.

I am grateful to Drs. Marion Anger and La Mont Gosser for suggestions concerning material taught by them in the Orthopedy courses of the Palmer School of Chiropractic. I am especially indebted to Dr. Loyal Fraser for the photographic illustrations which represent many hours of technical work. Miss Mary Korey was of great assistance in the typing of the manuscript and Mr. Fred Edwards of the P. S. C. printery has been most cooperative and helpful.

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Chapter 1

THE SPINAL COLUMN

EMBRYOLOGICAL DEVELOPMENT

It is perhaps significant that the first indication of a body framework to appear in the developing human embryo is the notochord which arises between the neural tube and the primitive gut as a direct outgrowth of the primitive knot. In certain lower forms of animals such as some marine-worms and fish-like creatures the notochord persists as the only axial skeleton ever developed. For such small water animals the cartilaginous notochord affords sufficient support to the back as well as excellent flexibility; but with greater size greater strength becomes a necessity, and in man the spinal column must support the weight of the body. Bone gives this needed strength and the jointed nature of the backbone permits a marked degree of mobility. Furthermore, the adjacent spinal cord is protected by the elements of the vertebrae.

Accordingly in most mammals, including man, the notochord exists for only a short time as an embryonic structure soon to be replaced by a more rigid and segmented spinal column. From the notochord and the paired mesodermal segments that appear along its lateral sides will be formed the greater part of the permanent bony and muscular framework of the body except for the extremities. The bones and muscles of the arms and legs originate from condensed areas of mesoderm appearing in the early embryo as two flat arm-buds and two flat leg-buds located near the cephalic and caudal ends of the embryo. These buds gradually elongate, differentiate into individual anatomical parts, and eventually assume the shape characteristic of arms and legs.

There are three fundamental structures concerned with the embryonic development of the human spinal column (1) the notochord, (2) the somites, and (3) the sclerotomes. If these

are understood a complicated process can be simplified to a logical sequence of events.

The Notochord or Chorda Dorsalis

The notochord is a primitive supporting structure which represents the beginning of the axial skeleton in every vertebrate. In man it is temporary, being replaced by the vertebral column, and its remains exist only as the mucoid **nuclei pulposi** of the intervertebral discs. The notochord, meaning back-cord, is derived from the embryonic mesoderm and extends from the region of the future sphenoid bone as far down as the coccyx area. It is one of the earliest recognizable embryonic structures, starting to appear at the eighteenth day as a long, flexible, rod-like form located in the median plane of the embryo near its dorsal surface.

So significant is this formation that all vertebrates and related animals are grouped as the phylum Chordata, a name referring to the presence of a notochord.

Somites or Mesodermal Segments

The entire development of the spine takes place around the central structure known as the notochord. During the fourth week of the embryo a series of primitive somites or mesodermal segments appear as paired block-like formations lying on each side of the median line next to the notochord. Most of these paired somites appear during the fourth week and their final number is 38 pairs: 1 for the occiput, 7 for the cervicals, 12 for the thoracic vertebrae, 5 for the lumbars, 5 for the sacrum, and 8 for the coccyx with several of these coccygeal somites failing to develop.

Each pair of somites is a mass of mesodermal tissue which expands around the neural tube and the notochord and will ultimately form many of the structures which make up the axial skeleton—the vertebrae, ribs, ligaments, muscles, in fact, all the connective tissues adjacent to the spinal column.

At the end of the fourth week each somite undergoes differentiation into three definite parts:

(1) The *sclerotome*—the antero-medial part of the somite and from which will come the vertebrae and the ribs.

(2) The *mytome* comprises the postero-lateral section of

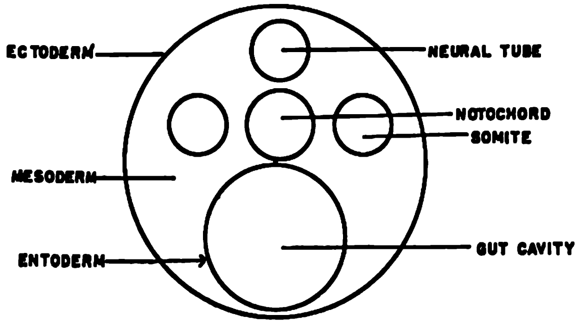


FIG. I

Fig. 1. Cross section of early embryo to show relationship of somites to notochord and neural tube.

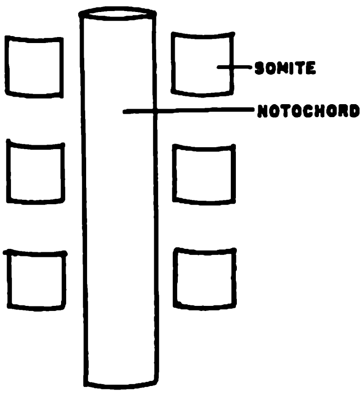


FIG. 2

Fig. 2. Longitudinal section of a portion of the developing spinal column showing a series of paired somites alongside the notochord.

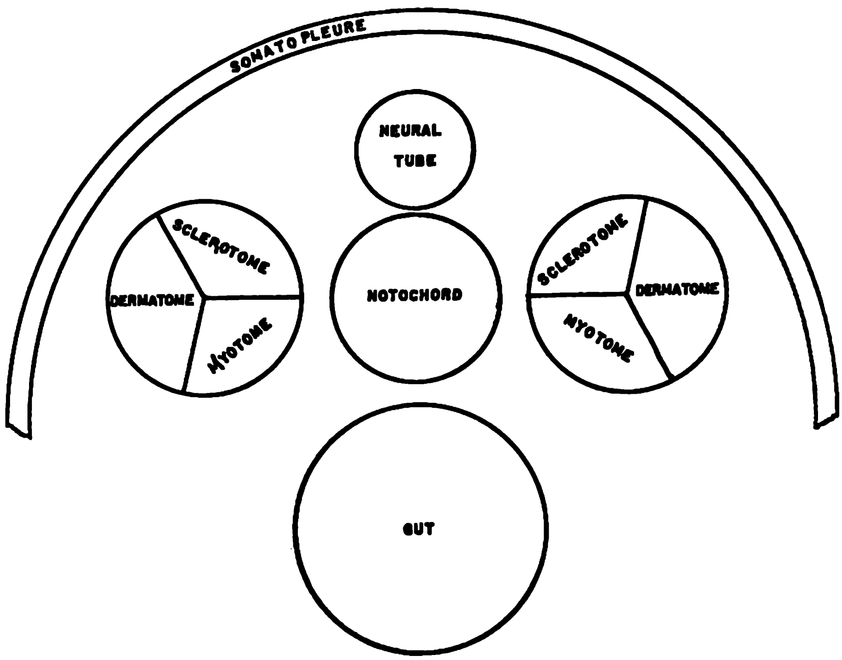


FIG.3

Fig. 3. Cross section of early embryo to show the differentiation of each pair of somites into paired sclerotomes, myotomes and dermatomes.

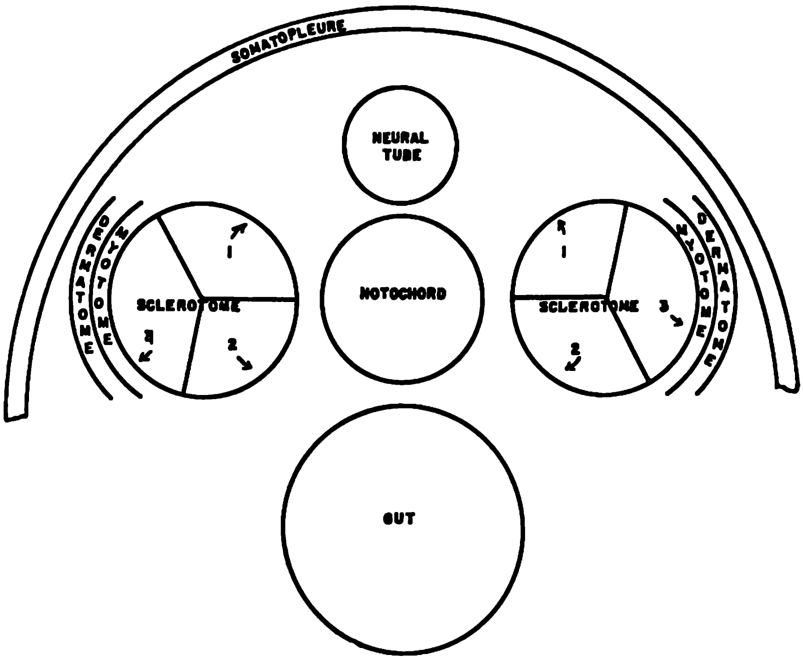


FIG. 4

Fig. 4. Cross section of embryo showing subdivision of somites into sclerotomes, myotomes and dermatomes.

Arrows show the direction of growth of the paired sclerotomes to form the vertebra and the ribs. 1. of the sclerotome develops into the vertebral body. 2. forms the vetebral arch, and 3. produces the costal process of the vertebra.

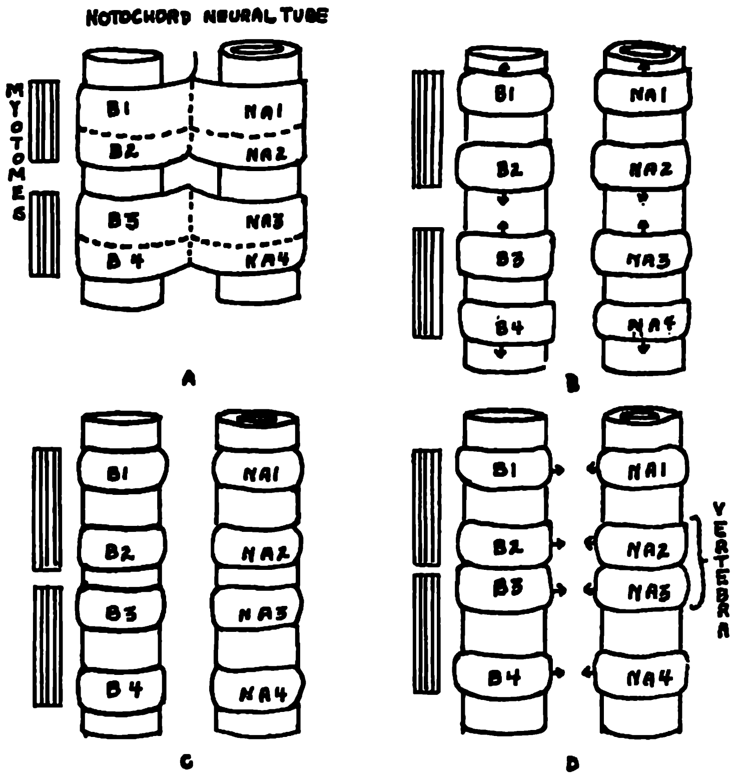


Fig. 5. Diagram to show development of vertebra from sclerotomes.

B1, B2, B3, B4 will become vertebral bodies, and NA1, NA2, NA3, NA4 represent neural arches. A, Four pairs of sclerotomes lying lateral to the notochord and neural tube. B, The more dense portions B2 and NA2 are separating from their original B1 and NA1 connections and the less dense B3 and NA3 portions are undergoing a similar separation from B4 and NA4. C, The components of a single vertebra are approaching each other—B2, B3, NA2, and NA3. D, Fusion has taken place to form the body and neural arch of a vertebra incorporating B2, B3, NA2, and NA3. A similar vetebral formation will occur by fusion of B1 and NA1 with corresponding halves of the somite above, and by fusion of B4 and NA4 with halves below. Note that the myotome is now in a position to attach to a developing vertebra above or below as the case may be. This arrangement is necessary for proper motion of the spinal column and related structures.

the somite and gradually differentiates and expands to form the axial musculature.

(3) The *dermatome,* which makes up the lateral part of the somite and will form the connective tissues of the skin over the torso.

VERTEBRAL DEVELOPMENT

There are three stages in the development of all vertebrae:

(1) Mesodermal or mesenchymal condensation of the screlotomes.

(2) Cartilaginous formation.

(3) Ossification.

(1) Mesodermal Stage

Each sclerotome becomes more dense on its caudal end and finally a fissure separates the cephalic and caudal halves of the sclerotome. This dense lower half joins the looser cranial half of the sclerotome next below and it is this new recombination which represents the primordia or beginning of the individual vertebrae. This recombination of sclerotome halves is not a useless developmental complication but rather is part of Innate's plan for proper function. The segmentally arranged axial and spinal muscles are powerful and are important to locomotion as well as to spinal motion. To exert their force properly they depend primarily upon attachment to the vertebrae and ribs and for effective attachments they must originate from or insert into at least two successive vertebrae. This is accomplished by the change of positions of the sclerotomes in relations to the original myotomes, as the latter remain fixed in the original somite. Thus the developing muscle will lie between two adjacent vertebrae or vertebral parts; otherwise a muscle would have its origin on a part of one vertebra and insert into another part of the same vertebra with the result that motion would be impossible.

From each bilateral pair of recombined sclerotomes a rapid growth of mesoderm takes place in three directions (1) medially, to surround the notochord and form the vertebral body; (2) dorsally, around the neural tube to form the neural or vertebral arch; and (3) antero-laterally, to form the transverse processes and the ribs.

The vertebral body or centrum arises from the lower, less dense part of each recombined sclerotome and the remaining vertebral descriptive parts and the ribs develop from the upper, more dense, portion.

Between each bilateral pair of sclerotomes an intervertebral fissure opens up and mesenchymal tissue derived from the surfaces of adjacent sclerotomes is squeezed into this fissure. This compressed tissue becomes the intervertebral disc. The crowding pressure of the sclerotomes uniting to form a vertebra eventually destroys much of the notochord except in the intervertebral fissures. Here the remains of the notochord is incorporated in the discs to become the nuclei pulposi. Accordingly, the only demonstrable remains of the notochord in the human spinal column is the nucleus pulposus of each intervertebral disc.

The surrounding mesenchyme has also been active during this stage differentiating into the longitudinal ligaments of the spinal column. The intersegmental arteries which have been providing the primary blood supply to all these tissues have also been displaced by the sclerotomic recombination and are now positioned in the midportion of the vertebral bodies in contrast to their original positions between adjacent sclerotomes.

(2) Chondrification of Cartilaginous Stage

Towards the end of the fourth week of fetal life the membranous vertebral column begins to be replaced by the cartilaginous vertebral column. Centers of chondrification appear first in the cervical vertebrae and rapidly invade the lower vertebrae. Two chondrification centers appear in the vertebral body and these soon grow together to form the body in cartilage. Another pair of chondrification centers appears in the lateral parts of the vertebral arch and grow backwards around the neural tube to transform the pedicles, laminae and the spinous process into cartilage. The four centers enlarge and gradually unite to form a solid cartilaginous vertebra which by the middle of the third fetal month completely encloses the spinal cord within the spinal canal. It is at this third month that two additional centers of cartilage formation appear in the arch areas and begin to lay down cartilage in the transverse processes and ribs.

This process of chondrification proceeds slowly until it has involved all the membranous vertebrae but it does not invade the intervertebral spaces. Instead, each space is surrounded by

a dense rim of cells destined to become the **annulus fibrosus** of the intervertebral disc. Located in the center of each disc is the remains of the notochord appearing as the swollen, mucoid nucleus pulposus.

(3) Stage of Ossification

In the tenth week the stage of vertebral ossification begins, and by the middle of the fourth month bone formations can easily be seen on x-rays of the fetal outline. Actually there are two periods of ossification; (1) primary, which takes place in the developing fetus, and, (2) secondary, occurring during the period of early adolescence.

The primary centers of ossification of the vertebral bodies appear first as a small anterior and a small posterior center which soon unite to form one large center of ossification for each vertebral body. The first centers appear in the lower thoracic and upper lumbar regions and extend rapidly upwards to the cervical region. The sacral and coccygeal segments are the last to show centers of ossification.

Ossification of the bodies of the vertebrae is specific for the bodies only; each lateral half of the vertebral arch has its own center of bone formation to ossify the pedicles and laminae. Thus, each developing vertebra shows three primary centers of ossification which appear at a predetermined time for that particular vertebra. All vertebrae are not undergoing ossification simultaneously; indeed, the sacrum at the fifth fetal month is just beginning to show ossification centers whereas the other spinal segments are well along in their osseous development. However, it must be understood that the complete union of primary bony components of each vertebra is not completed until several years after birth. Failure to take this into account is the reason for many incorrect spinographic analyses in which "anomalies" and "fractures" are listed; when in reality these spaces are merely cartilage synchondroses not yet ossified. It is not until the third year of life that the bodies of the cervical vertebrae are united with the arches on either side; in the lower lumbars this union is not completed until the sixth year.

Secondary centers of ossification begin to appear at the seventeenth year on the tips of the spinous processes, tips of the transverse processes, and most important, in the cartilage still covering the upper and lower surface of each vertebral body

as the disc-like bony epiphyses or epiphyseal plates. Most vertebrae show these five secondary centers of ossification; one for each epiphyseal plate, and one for the tip of each transverse and spinous process. These centers fuse with the rest of the bone at approximately the age of twenty-five.

VARIATIONS IN DEVELOPMENT OF CERTAIN VERTEBRAE

The Occiput

The large dish-shaped area of the occipital bone is called the **squama** and that part of the squama which lies above the highest nuchal lines is termed the **planum occipital.**

The planum is first developed in membrane whereas the remainder of the occiput is preformed in cartilage.

There are four centers of ossification for the planum occipital: two appear near the median line at the second fetal month and one in each lateral half at the third month.

The **planum nuchale,** or that part of the squama below the highest nuchal line, ossifies from two centers appearing about the seventh fetal week soon after which they unite to form a single center of ossification.

At the end of the third month the four centers of the planum occipital and the single center of the planum nuchale come together to form the major part of the occiput.

Each of the lateral portions of the occipital bone located to either side of the foramen magnum begin to ossify at the eighth fetal week. There is a single center in each lateral part.

The **basilar portion** is ossified from a single center first showing at the sixth fetal week.

It is not until four years after birth that the two lateral portions and the squama are completely united by bone, and finally at the sixth year the basilar part fuses with these to form the single occipital bone.

The occiput thus shows a total of eight ossification centers: four in the planum occipital, one in the planum nuchale, one in each lateral portion, and one in the basilar part.

The Atlas

The atlas is usually ossified from three centers: one for each lateral mass appears at the seventh week of fetal life followed by a single center for the anterior arch. This center shows a delayed appearance as it is not present until the time of birth.

The two lateral mass centers extend backwards and by the time of birth they have nearly joined in the posterior median line, being separated only by a narrow cartilage-filled space corresponding to the site of the posterior tubercle.

The anterior arch of the atlas consists of cartilage at birth but soon an ossification center forms in the region of the anterior tubercle. Gradually this bone formation spreads through the anterior arch until at the sixth to the eighth year it has joined with both lateral masses.

It is said that the main part of the atlas representing its embryonic body arises as usual but soon fuses with the body of axis to become indentified as the odontoid process of the latter. This detachment of its body gives the atlas its typical ring-like shape.

Axis or Epistropheus

The axis is ossified from five primary and two secondary centers. The body of axis and its neural arch ossifies in the same manner as a typical vertebra; namely from a single center in the body and one center in each lateral half of the neural arch. The centers for the arch appear about the second month of fetal development and that for the body about the fourth or fifth month. At this time too the odontoid process is forming as an upward projection of the cartilaginous mass from which the body of axis is being formed. (As mentioned previously the bulk of the odontoid may be considered either as the body of atlas which has detached and moved into position above the body of axis or it may be viewed as a developing part of axis. In any event, and most important, the atlas has no body in its final form.) At the sixth fetal month two laterally situated centers of ossification appear in the base of the odontoid process. This completes the formation of the five primary centers of ossification.

It should be kept in mind however that the base of the odontoid process and the axis body remain separated by a thin cartilaginous disc which ossifies very slowly and in some cases does

not become bone until about the eighteenth year of life. This disc represents a rudimentary epiphyseal plate on the upper surface of the axis body and is sometimes mistakenly interpreted on lateral cervical spinographs as a fracture between the odontoid and axis body. In such views of young children particularly it appears as a thin clear line between these two parts of the axis vertebra.

A secondary center of ossification develops in the apex of the odontoid during the second year and by the twelfth year this has united with the rest of the odontoid process. Because of the cartilaginous make-up of the odontoid apex during childhood this area may also be a source of incorrect spinographic analysis, the clear non-ossified apex being considered as an anomaly when in reality it is a normal manifestation of Innate Intelligence.

Secondary center number two locates on the inferior surface of the axis body where it proceeds to form a thin epiphyseal plate.

The Seventh Cervical

The seventh cervical vertebra has the usual three primary centers of ossification: one for the body and one in each half of the neural arch. However, the transverse processes of this vertebra occasionally show a second center of ossification in the anterior or costal process which normally unites with the true transverse process. Sometimes this anterior portion will persist as a separate structure forming what is known as a cervical rib which condition is described in detail under Congenital Anomalies.

The Lumbar Vertebrae

Besides the usual three centers of ossification all lumbar vertebrae exhibit two additional centers making a total of five for each lumbar. From these two extra centers develop the mamillary processes, two small prominences on the postero-lateral aspects of the superior articular processes.

In rare instances the transverse processes may form as separate structures and never unite with the vertebral body which condition is called a **lumbar rib.**

The Sacrum

During the early years of life the sacrum is made up of five segments known as the sacral vertebrae. The body of each sacral vertebra ossifies from a single primary center but there is also a center in each of the epiphyseal plates found on the superior and inferior surfaces of the body. Ossification begins in the central portions of the bodies of the upper three sacral segments at the eighth fetal week but it is not until the sixth, seventh or eighth fetal month that the bodies of the fourth and fifth segments begin to undergo bone formation. The aforementioned epiphyseal plates above and below each vertebral body do not make their appearance until close to the sixteenth year of life.

On each lateral surface of the sacrum two more epiphyseal plates form between the eighteenth and twentieth years. These lateral plates are concerned with the auricular surface ossification as well as the remainder of the lateral sacral surface. Each vertebral arch of the sacrum is ossified from two centers which become active during the sixth fetal month and finally unite with the sacral bodies at the second year. This osseous junction begins in the lower sacral segments and is completed in the upper segments by the sixth year.

The anterior portions of each lateral part of the sacrum show six ossification centers; two for each of the upper three sacral vertebrae. These correspond to the costal elements of a typical vertebra and make their appearance at about the sixth fetal month. When they complete their bone formation they may be identified as having formed the superior and lateral margins of the anterior sacral foramina.

During early life the bodies of the sacral vertebrae are separated from each other by intervertebral fibrocartilages. At the age of eighteen the cartilages between the third and fourth and fourth and fifth segments undergo ossification followed gradually by similar changes in the upper fibrocartilages so that at the age of twenty-five the sacrum becomes a single solid bone.

The Coccyx

Each of the four coccygeal segments exhibits only one center of ossification, all of which appear after birth. The first, or uppermost, arises between the first and fourth year, the second

between the fifth and tenth years, the third between the tenth and fifteenth years, and the fourth between the fourteenth and twentieth years. Gradually the segments fuse with one another until at the twenty-fifth year the coccyx is usually a single osseous structure. It is quite common that the coccyx will also fuse with the sacrum apex later in life.

ANATOMY OF THE SPINAL COLUMN

General Description

The spinal column, or vertebral column, is a flexible formation composed of vertebrae and located in the posterior median line of the body for which it serves as the main longitudinal support.

Chiropractic anatomy makes a distinction between the spinal column and the spine although these two terms are used interchangeably by most anatomy texts. From the chiropractic standpoint the adult **spinal column** is made up of 26 vertebrae; 7 cervical, 12 dorsal, 5 lumbar, 1 sacrum and 1 coccyx. The **spine** is considered as the 24 movable vertebrae excluding the sacrum and coccyx.

During the period from infancy to early adulthood at about the twentieth year the spinal column shows a total of 33 vertebrae; 7 cervical, 12 dorsal, 5 lumbar, 5 sacral, and 4 coccygeal. The sacral and coccygeal segments gradually fuse with their respective members and eventually form a single sacrum and a single coccyx.

Length of the Spinal Column

The average adult male spinal column measures from 27½ inches to 28¾ inches; the average female spinal column is three inches less in length or about 25 inches.

The lengths ascribed to the different regions of the spinal column may be considered as follows; the cervical 5 inches, the thoracic 11 inches, the lumbar 7 inches, and the sacrum and coccyx combined 5 inches. Obviously the length of the male **spine** is about 23 inches and the female **spine** 20 inches due to the exclusion of the 5 inches represented by the combined lengths of the sacrum and coccyx.

It must be kept in mind that the length of the vertebral column is not entirely dependent upon the thickness of the individual vertebral bodies but that the intervertebral discs also contribute to this length. In fact, the discs are responsible for about one-fourth of the total length of the column so an over-all length of 28 inches can be accounted for as being 21 inches of bone segments and 7 inches of intervertebral discs. It is normal for some dehydration and shrinkage of the discs to accompany old age which accounts for part of the apparent loss of height in a person of advanced age. There are also indications that the normal spinal column will show daily fluctuations in length of as much as three quarters of an inch decrease due to temporary compression and shrinkage of the discs. However this condition is corrected during sleep and rest and the spinal column maintains a relatively constant length from day to day.

Curves of the Spinal Column

In early fetal life the spinal column viewed laterally is shaped like the letter C; the thoracic and sacral curves of the adult represent the remains of this single long curve.

The thoracic and sacral curves are called primary curves or accommodation curves as they persist from the fetal state. They are concave forward to accommodate the thoracic and pelvic viscera. Soon after birth Innate begins to form two other curves in the spinal column and these are known as secondary curves or compensation curves because they are adaptative to certain requirements of posture.

The secondary curves are the cervical and lumbar curves; both are convex anteriorly. The cervical curve appears when the child first starts to hold up its head at three months and is well formed at six months when the infant sits up. The cervical curve is not a fixed curve as it tends to straighten when the person assumes a supine position.

The lumbar curve develops between the ages of nine and twelve months when the child begins to stand and to walk. It is a well established curve at the eighteenth month in most children.

When all four spinal curves are established a profile view of the spinal column presents a figure similar to the letter S. Both cervical and lumbar curves represent a means of better balancing the weight of the body and as such may become greatly ex-

aggerated by adaptation to a shift forward of the body's center of gravity in such conditions as obesity, pregnancy, poor posture or nerve interference decreasing the tonicity of certain spinal muscles.

The shape of the spinal column is still another evidence of the supreme engineering skill of Innate Intelligence as it is estimated that the four alternating curves give sixteen times more strength to the spinal column than if it were constructed in a straight line.

Locations of the Curves

The cervical curve, convex to the anterior, begins at the apex of the odontoid and ends at the second dorsal body with its most anterior point being the body of the fourth cervical.

The thoracic curve, concave to the anterior, starts at the second dorsal and extends down to the twelfth dorsal; its most prominent portion is at the body of the seventh or eighth dorsal vertebra. The lumbar curve, convex to the anterior, begins at the twelfth dorsal and ends at the junction of the fifth lumbar and the sacrum. This curve is slightly more pronounced in the female than in the male.

The pelvic curve, concave to the anterior, begins at the junction of the fifth lumbar and the sacrum and is completed at the tip of the sacrum.

In addition to these four normal curves of the spinal column one other curve is sometimes described as the lateral secondary curve appearing in the midthoracic region. It is considered as being compensatory to either the crowding presence of the aortic arch and thoracic aorta which gently displace the thoracic vertebrae slightly right of the median line, or to the very slight lateral curve observed in most right-handed people resulting from greater use of the right upper extremity. This is sometimes called a physiologic right lateral curve and is an excellent illustration of the adaptative powers of Innate Intelligence.

Relation of the Intervertebral Discs to Spinal Curves

Although the curves of the spinal column are primarily a function adaptation their appearance is accompanied by certain anatomical changes as well. The bodies of the vertebrae show differences in thickness at their anterior and posterior borders

and this inequality is also expressed in the intervertebral discs, where it is usual to find the anterior portion thicker than the posterior half. This slight wedging of the bodies and discs accounts for the formation of the curves.

GROSS APPEARANCE OF THE SPINAL COLUMN

Anterior View

When viewed from in front the transverse width of the bodies of the vertebrae is seen to increase or decrease gradually from one level to another. Two major pyramidal forms may be noted (1) from the axis to the fifth lumbar, (2) from the base of the sacrum to the tip of coccyx. In turn, close observation reveals three smaller pyramids subdividing the upper major one.

The first of these subdivisions has its apex at the axis odontoid and extends down to the body of the first dorsal which forms its base.

The second is an inverted pyramid having its base at the body of the first dorsal and its apex at the level of the fifth dorsal.

The third small pyramid has its apex at the fifth dorsal and its base at the fifth lumbar vertebra.

This variation in the width of the vertebral bodies at different levels is an indication of the comparative size of the neural canal at these levels. It will be noted that the areas showing the greatest width correspond rather closely to the locations of the cervical and lumbar enlargements of the spinal cord.

Posterior View

The outstanding vertebral structures observed on a posterior view are the spinous processes. In the cervical region the spinouses are short, horizontal and bifid except in the case of axis and seventh cervical which are atypical cervical vertebrae. The upper-thoracic spinouses are directed obliquely to the inferior, in the middle thoracic region they are almost vertical, and in the lower thoracic region they project backwards almost horizontally. The spinous processes are rather close together in the cervical region, very close together in the mid-dorsal region, and most widely separated in the lumbar region.

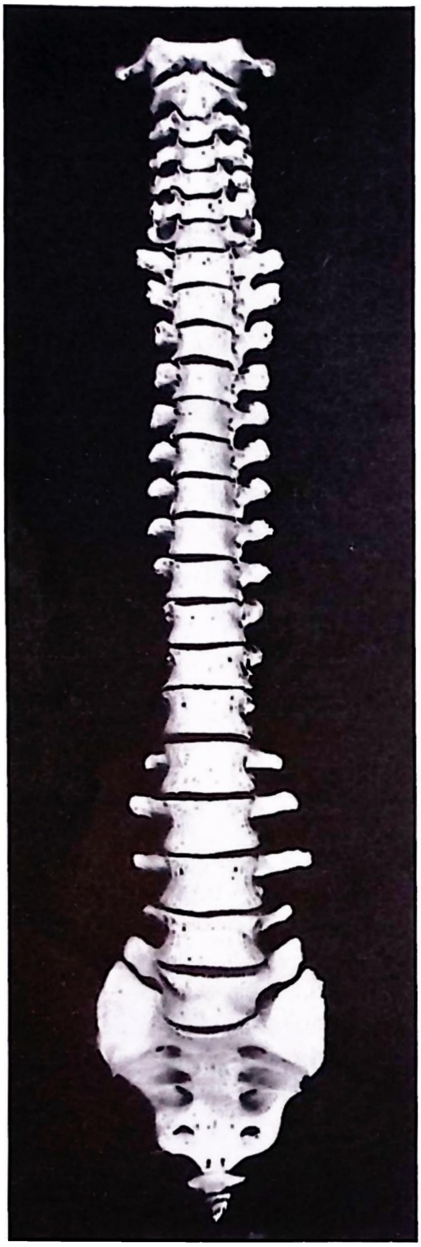


Fig. 6. Anterior view of the spinal column.

Fig. 7. Posterior view of the spinal column.

A vertebral groove lies to either side of the spinous processes. Each groove is shallow in the cervical and lumbar regions where its floor is formed by the laminae but in the thoracic region the vertebral grooves are broad and deep as their floors are made up of the laminae and the transverse processes of the thoracic vertebrae. The vertebral grooves lodge the deeper layers of the back muscles. In the lumbar region the bulge of these muscles beyond the tips of the spinouses produces a shallow median depression known in topographical anatomy as the lumbar furrow.

Lateral to the vertebral grooves are the articular processes of the vertebrae and lateralmost are the tranverse processes. The tranverse processes of the thoracic vertebrae project more to the posterior than do those of the cervicals and lumbars. In the cervical region the transverses are anterior to the articular processes, lateral to the pedicles and between the intervertebral foramina. The thoracic transverses lie posterior to the articular processes, pedicles, and intervertebral foramina. In the lumbar region they are anterior to the articular processes but posterior to the intervertebral foramina.

Lateral View

The lateral surfaces of the spinal column present the sides of the vertebral bodies, their processes, and the intervertebral foramina which have always been of particular interest to chiropractic science.

The Intervertebral Foramina

There are 31 pairs of intervertebral foramina which are openings between the segments of the spinal column for the transmission of the spinal nerves. They are formed by the juxtaposition of the vertebral notches and are ovoid in shape, being smallest in the cervical region and gradually increasing to their maximum size in the lower lumbar region. They lie between the cervical transverse processes but are in front of the thoracic and lumbar transverses. The foramens are altered in size by the movements of the spinal column: when the neck is flexed forward the cervical foramina are increased in diameter, and they are decreased in size with backward cervical flexion.

The same is true in the lumbar region, i.e., anterior flexion here will increase the diameter of the foramens whereas posterior extension decreases the size of these openings. Since the

Fig. 8. Lateral view of the spinal column. Note the normal curves.

thoracic region shows limited motion in either anterior or posterior bending the size of these foramina is relatively constant. The foramina of the atlanto-axial region differ from those of other regions of the spine. The pair located superior to the atlas are found posterior to the superior articular surfaces of the lateral masses. The second pair of intervertebral foramina are formed between the inferior surface of the atlas posterior arch above and the superior surface of the axis laminae below. These two surfaces show shallow grooves which are converted into foramina by the posterior atlanto-axial ligament. The intervertebral foramina of the sacrum and coccyx also vary from the usual arrangement found between the vertebrae. Running through the sacrum from superior to inferior is the sacral canal which transmits the cauda equina, filum terminale, and certain blood vessels. On each lateral wall of the sacral canal there are four intervertebral foramina which communicate with both the anterior and posterior sacral foramina.

The four pairs of anterior sacral foramina decease in size from above downwards and represent openings between the five fused sacral vertebrae.

They convey the anterior divisions of the first four sacral nerves. The posterior sacral foramina, also four pairs, lie directly behind the anterior foramina and open onto the dorsal surface of the sacrum. They also decrease in size from above downwards, and the diameter of each pair is smaller than its corresponding anterior pair. The posterior sacral foramina transmit the posterior divisions of the first four sacral nerves.

The only structure on the coccyx resembling an intervertebral opening is found between the articulating coccygeal cornua and sacral cornua. These small paired foramina allow the passage of the posterior divisions of the fifth sacral nerve.

Boundaries of the Intervertebral Foramina

With the exceptions of the atlas-axis group and the sacrum and coccyx, the remainder of the foramina are formed according to a regular pattern. The roof is formed by the vertebral notch on the pedicle of the superior vertebra and the floor by the notch on the pedicle of the inferior vertebra. The posterior wall of each foramen is formed by the superior articular process of the vertebra below and a small part of the lamina of the vertebra above.

The anterior wall is bounded by the intervertebral disc and a small part of the posterior body surfaces of the two adjacent vertebrae, except in the dorsal region where no part of the body of the inferior vertebra contacts the intervertebral foramen.

Even though the intervertebral foramina appear small in diameter it should be kept in mind that in the living body Innate permits no waste space and that each foramen is completely filled with structures. About one fourth of each foramen is filled with the spinal nerve roots, the posterior root ganglion, and the beginning nerve trunk, the remaining three fourths being occupied by the spinal artery, intervertebral vein, spinal lymphatic, fat and other tissues.

INTERVERTEBRAL DISC

The usual anatomical consideration of the intervertebral disc places it among the ligaments and articulations of the vertebral column, and of course the disc is correctly listed as one of the important spinal ligaments. However, because of its great importance to the Chiropractic study of the vertebral column and particularly because of its clinical involvement in many spinal conditions an extensive approach to the anatomy of the disc is justified at this point in the anatomy of the column.

The intervertebral discs or intervertebral fibro-cartilages are 23 pad-like structures uniting the vertebral bodies from the axis inferior surface to the 5th lumbar inferior surface and 1st sacral superior surface. There are no discs between occiput and atlas, nor between atlas and axis; these articulations being of a diarthrodial arthrodial condyloid, or diarthrodial trochoides type, rather than the amphiarthrodial symphysis found between all other vertebral bodies.

The discs vary in size, shape and thickness in different regions of the spinal column. In size and shape they conform closely to the size and shape of the vertebral bodies which they join except in the cervical region where they are slightly narrower than the bodies of these vertebrae. They show variations in thickness in each of the spinal regions being thin in the cervical region and becoming gradually thicker as they approach the dorsal and lumbar regions. The most important feature of their variable thickness however is in the differences found in the an-

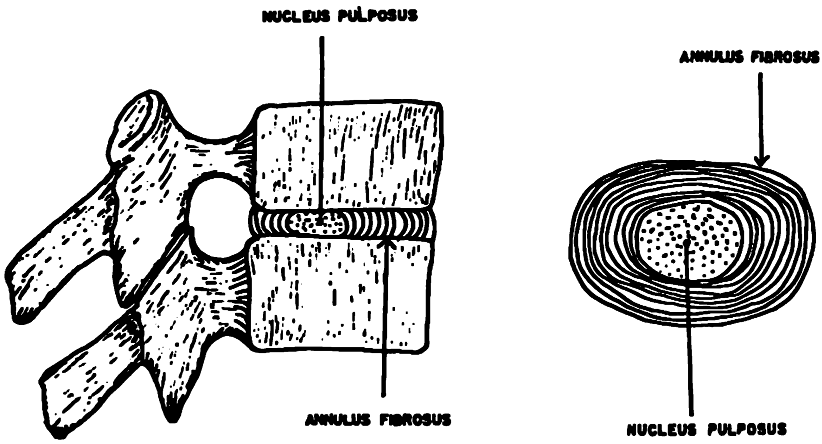


Fig. 9. The intervertebral disc.

terior and posterior halves of each individual disc. In both the cervical and lumbar regions the discs are thicker at the anterior than at the posterior and thus they contribute to the anterior cervical and lumbar curves. In the dorsal region the discs show equal thickness in their anterior and posterior portions and the dorsal curve is produced mainly by the shape of the thoracic vertebral bodies. These two points may be easily understood by studying a spinal specimen.

The stooped posture of old age with its accompanying anterior flexion of the spinal column may in part be explained by the tendency of all intervertebral discs to lose their resiliency with advancing years and to flatten out so that the secondary spinal curves are decreased. Since the sum total of all the discs equals about one-fourth the over-all length of the spinal column, it follows that a thinning of the discs will decrease the apparent height of the individual as these changes occur in old age.

Anatomically, each disc consists of two parts, (1) the annulus fibrosus (2) the nucleus pulposus.

The Annulus Fibrosus forms an envelope around the nucleus pulposus and is made of thick, tough fibrocartilage which is arranged in concentric lamellae of interlacing white fibers giving the annulus fibrosus great strength.

The fibers are so arranged in layers that those of any two adjacent layers run almost at right angles to each other, the fibers crossing like the limbs of the letter X.

This fibrocartilage is fused to the epiphyseal plates of adjacent vertebrae and when the plates unite with the vertebral bodies during early adult life each disc becomes still more securely anchored to the two vertebral bodies which it separates.

The Nucleus Pulposus is a soft, semigelatinous, highly elastic tissue, yellowish in color, and located near the center of the disc. Each nucleus is about one half inch in diameter and is oval in shape and is thicker from above downward than its surrounding annulus fibrosis. Each nucleus pulposus represents the sole remains of the embryonic notochord.

Much of the shock absorbing action of the spinal column is done by the nuclei pulposi of the intervertebral discs, as under pressure the highly elastic nucleus becomes flattened and broadened and pushes the more resistant annulus fibrosus outwards

in all directions. It is estimated that in the average healthy young adult the nucleus pulposus is under a pressure of 30 pounds to the square inch.

Each disc is firmly attached at its outside margin to the anterior and posterior longitudinal spinal ligaments. In the thoracic region the discs are also joined by interarticular ligaments to the heads of those ribs attaching to two adjacent vertebrae.

The blood supply to the intervertebral discs is by way of branches from the spinal arteries which are evident in the annulus fibrosus up to middle age, then show gradual regression with advancing age. It is probable that nourishment of the nucleus is accomplished by osmosis from the surrounding capillaries.

Nerve Supply to the intervertebral disc had never been satisfactorily described until recently. Previously the discs had been considered in the light of mechanical, inert tissue, but recent studies have shown clinical evidence of such a supply. It is well known that nerves are distributed freely to the vertebral bodies and the periosteum of the vertebral processes.

Chiropractic science has long maintained the need for a nerve supply to the intervertebral disc and this position is rapidly being justified.

FUNCTIONS

Six functions of the intervertebral disc may be considered.

1. They absorb shocks to the body.
2. They attach the vertebral bodies together.
3. They separate the vertebral bodies.
4. They give shape to the spine by forming the secondary curves.
5. They act as powerful ligaments.
6. They help to form part of the anterior wall of the intervertebral foramina.

SPINAL CANAL—VERTEBRAL CANAL—NEURAL CANAL

The spinal canal runs from the foramen magnum above to the sacral apex below, forming a bony tube through which

passes the spinal cord and its meninges. Its anterior wall is formed by the posterior surfaces of the vertebral bodies, and its lateral and posterior bony boundaries are made up of the pedicles and laminae of each vertebra.

The pedicles and laminae of each vertebra form an anatomical descriptive part called its **Neural Arch** or **Vertebral Arch.**

The body of each vertebra plus its pedicles and laminae form a ring-like structure called the **Neural Ring** and thus the neural canal or spinal canal is merely the sum total of all the 24 neural rings of the movable vertebrae in addition to the vertebral canal or sacral canal running throughout the length of this bone.

The spinal canal follows the different curves of the spinal column and varies in size and shape in different spinal regions. It is larger in the cervical and lumbar regions where freedom of motion is greatest, and smaller in the thoracic region which shows restricted motion.

Cervical Region—

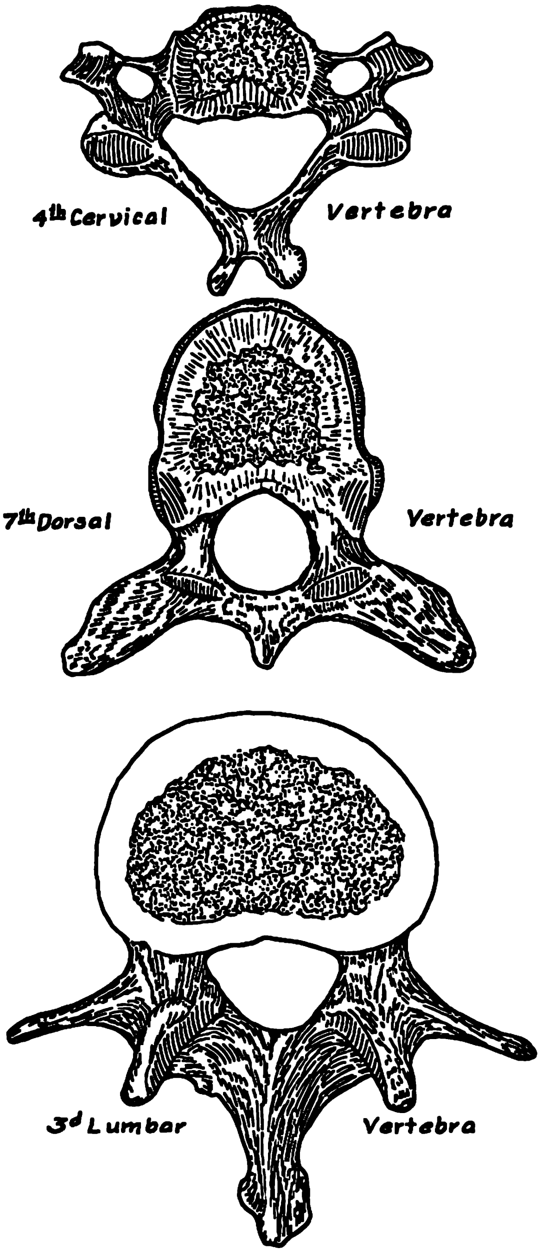
A cross section of the spinal canal in the cervical region shows a triangular shape with the base of the triangle represented by the vertebral bodies because the width of the bodies is greater than the length of the vertebral arches, thus the transverse diameter is greater than the antero-posterior diameter. The cervical spinal canal is the largest in adaptation to the greater cervical mobility and the cervical spinal cord enlargement.

Thoracic Region—

The thoracic part of the vertebral canal is smaller in size than in the cervical region and its shape is nearly circular. In this region the pedicles are not set so far apart at the point where they are attached to the bodies, so the transverse and anteroposterior diameter are about equal length.

Lumbar Region—

In the lumbar region the vertebral canal again assumes a larger size and the triangular shape similar to that found in the cervical area. The lumbar canal is the second largest of all spinal



Figs. 10, 11, 12. Shape of the vertebral canal in the different regions of the spine.

canal regions because of the diffuse spreading of the spinal nerve roots making up the cauda equina which runs down through this region.

Sacral Region—

The vertebral canal runs almost the length of the sacrum and is triangular in the upper half while in the lower one half its posterior wall is incomplete due to the absence of laminae and spinous processes. The sacral nerves pass through the sacral canal and emit through the anterior and posterior sacral foramina opening off the canal.

BLOOD SUPPLY OF THE SPINAL COLUMN

The spinal arteries which supply the vertebrae, the intervertebral discs, and other spinal ligaments, as well as the spinal cord and its meninges are derived from branches of the vertebral, deep cervical, ascending cervical and suboccipital arteries in the cervical region.

In the thoracic region they arise from the posterior branches of the intercostal arteries, and from posterior branches of the lumbar arteries in the lumbar region. The blood supply to the sacrum is by way of lateral branches of the sacral arteries.

In all regions of the spinal column the paired spinal arteries enter the neural canal through their corresponding intervertebral foramina and each immediately gives off three branches:

(1) Neural Branch—supplying the spinal cord, meninges, and the spinal nerve roots and spinal nerve adjacent to the neural branch.

(2) Post Central Branch—to the vertebral arches and the ligamentum flava.

(3) Pre-Laminar Branch—to the bodies of the vertebrae.

Drainage of the venous blood from the spinal column and its contents is accomplished by an extensive and complex network of relatively large veins running the entire length of the spine.

These veins do not have valves, and all of them eventually drain into spinal or intervertebral veins which lie alongside the spinal arteries in the intervertebral foramina. The spinal veins in turn empty into corresponding local veins such as intercostals, lumbars, etc.

The spinal venous system may be considered as being made up of two main collections of veins or venous plexuses.

1. Internal Venous Vertebral Plexuses or Intraspinal Plexuses run vertically inside the vertebral canal between the dura mater and the inner surfaces of the vertebral canal. These plexuses are made of four large longitudinal veins, two anterior and two posterior. The two anterior longitudinal veins, also known as the anterior internal vertebral plexuses, run down the posterior surfaces of the vertebral bodies and intervertebral discs and lie on either side of the posterior longitudinal spinal ligament. Running through the bone of each vertebral body is a basivertebral vein which drains into either or both of the anterior longitudinal veins.

The paired posterior longitudinal veins, or posterior internal vertebral plexuses, are located anterior to the neural rings and the ligamentum flava and after draining the body, pedicles, and laminae they pass directly through the ligamentum flava to empty into the veins of the posterior external plexus.

It will be noted that the anterior and posterior longitudinal veins and other anastomosing branches of the internal venous vertebral plexuses form a series of venous rings at the level of each vertebra.

2. The External Venous Vertebral Plexus is also composed of two groups of plexuses found on the outside of the vertebral canal. The anterior external vertebral plexus lies in front of the vertebral bodies which they help drain by communications with the basivertebral veins.

The posterior external vertebral plexus forms a network over the spinous processes, pedicles, laminae, transverses and deep spinal muscles.

The internal venous vertebral plexus and the external venous vertebral anastomose freely with each other and the blood collected by both of them finally is drained into the intervertebral or spinal veins of the intervertebral foramina.

LYMPH DRAINAGE OF THE SPINAL COLUMN

An extensive network of the lymph capillaries pervades the bone and other tissues of the spinal column. Arising from the capillaries are lymph vessels which anastomose freely and ultimately drain into large vessels which in turn end in the large veins of the root of the neck.

Lymph drainage of the lower six thoracic vertebrae is by way of a pair of descending trunks which pass through the aortic opening of the diaphragm and empty into the thoracic duct just above the cisterna chyli in front of the 2nd lumbar body.

The upper six thoracic vertebrae are drained of lymph by the upper posterior intercostal lymphatics.

The lumbar and sacral lymphatics provide lymph drainage from these two regions of the spinal column. Specifically, the superficial circumflex iliac vessels are concerned with the lumbar region while the sacral region shows drainage through the superior and inferior gluteal and obturator vessels. All of these vessels empty into the cisterna chyli.

In the cervical region the lymph system exhibits a large number of vessels and nodes. Drainage from the cervical vertebrae is primarily by way of the deep cervical lymphatics which end in either the right or left jugular trunk.

FUNCTIONS OF THE SPINAL COLUMN

The spinal column probably exhibits more varied functions than any other anatomical unit of the human body. Certainly the Chiropractor should be cognizant of its unusual versatility in function as well as knowing in complete detail the salient anatomical features of this engineering marvel. The following are its most important and most obvious functions:

1. **Protection**—The spinal column provides a protecting bony wall around the spinal cord.

2. **Support**—The spinal column supports the head and the upper extremities so that these structures may move smoothly and support strains put upon them.

3. **Weight-Bearing**—The weight of the body, exclusive of the lower extremities, is supported by the spinal column.

4. **Shape and Position**—The spinal column helps hold the body erect, as well as providing the natural body contours.

5. **Resiliency**—The ability of the spinal column to absorb much of the jars and shocks which might otherwise damage the brain or other viscera.

6. **Motion**—Its flexibility allows the spinal movements of flexion, extension, lateral flexion and rotation.

7. **Transmission**—The spinal column provides a channel for the entire spinal cord, and the intervertebral foramina provide transmission for the spinal nerves and other structures going to and from the spinal cord.

8. **Skeletal Formation**—The thoracic region of the spinal column forms part of the posterior thoracic wall and also provides attachment for the ribs.

9. **Stabilization**—The vertebrae and their attached muscles play a major part in the stabilization of the entire body. This can be easily observed in many spinal conditions which make any posture or locomotion painful or difficult.

Chapter 2

THE VERTEBRAE

THE STRUCTURE OF A VERTEBRA

Each vertebra of the adult spinal column is composed of bone; a hard specialized connective tissue with an intercellular substance of calcified collagenous material. Because of its great strength and hardness, bone provides adequate protection for the delicate spinal cord and other contents of the neural canal. Its structure, both macroscopic and microscopic, is so well adapted to its functions of protection and support that these are accomplished with the minimum of weight and material in the individual vertebrae.

Bone is one of the hardest substances in the human body, and it also possesses properties of elasticity and toughness. Fresh specimens of bone tissue are pinkish-white externally, and deep red internally.

Essentially, bone consists of a fibrous connective tissue imbedded in a more solid matrix: the matrix of bone is a hard, opaque, calcified material containing salts in which phosphate and carbonate are combined with calcium in complex manner. These calcium salts are responsible for the degree of hardness of bone. In the pre-puberty years, bone shows more fibrous tissue than salt content which makes the bone tissue tough but not hard. Thus, the bones of a child may be deformed by abnormal pressures and stresses such as poor posture or spinal curvatures. In the adult, balance between the fibrous connective tissue and mineral salts reaches its optimum level, and bone tissue possesses a maximum of hardness as well as toughness. In old age, there is a gradual loss of connective fibrous tissue with a resulting overbalance of mineral salts so that bone tissue is now hard, but no longer tough and is relatively easy to fracture due to its fragility.

Types of Bone—Hard and Soft

If the body of a vertebra is sawed in two, it will be seen that two typical forms of bone are present. The outer bone layer appears dense in texture; while the inner portion has a spongy appearance. Actually, the two types of bone are very similar, being merely different arrangements of the same tissue elements.

1. **Hard Bone**—is also known as compact bone, and may be compared to ivory. It forms a relatively thick layer or crust over the entire outside portion of a vertebra—body, processes, etc. Observing the compact bone under a microscope discloses a porous texture with many small cavities separated by large amounts of solid matter. Most of this solid material, or bone matrix, is made up of layers or lamellae, which, by their tubular forms, give the great strength to withstand stresses normally placed upon the bone.

2. **Soft Bone (Cancellous, or Spongy Bone)**—is made up of connecting and intercrossing bars or spicules of bone tissue which separate and surround large spaces containing bone marrow. This arrangement of large cavities and a smaller quantity of solid matter is the main difference between the formation of soft and hard bone, as in the latter, the proportion is reversed.

Soft bone forms the bulk of the vertebra being found under the layer of compact bone.

Minute Structure of Both Hard and Soft Bone

Bone is composed of layers, or lamellae, which consist of very small fibers imbedded in a calcified matrix. Between the lamellae are oval bone spaces, or lacunae, each containing a bone cell or osteocyte. As each bone cell gives off numerous fine branches, the bone space containing it also gives off many fine passages, the canaliculi which penetrate the hard interstitial matrix, branching and anastomosing, so that all the lacunae and canaliculi of a bone are connected into one continuous system. Compact bone, in particular, is pierced by tubes, the Haversian Canals, which contain blood vessels and nerves. The Haversian Canals are united to each other by oblique communicating channels, and some of the canaliculi open into them to complete an extensive network for the transmitting of nutrition and nerve supply. Similar channels known as Volkmann's canals, pierce the bone from the outer and inner surfaces and communicate with

the Haversian canals to further complete the system of channels. The small collagen fibers of the lamellae run parallel with one another within each lamella, but the direction varies in different lamellae. In addition to these fine fibers, the bone is perforated by heavier fibers, the **perforating fibers of Sharpey**, which arise from the periosteum; these are most numerous at the points of attachment of ligaments and tendons and serve to strengthen these points.

The directions and arrangements of the lamellae are adapted to various stresses and tensions which the vertebrae have to meet in the multiple actions and movements of the spinal column. The loose network of intricately interlacing fibers provides the light weight, and the great strength of bone. The strength of bone has been determined by measuring its resistance to pressure, and results indicate bone tissue to be stronger than granite or oak, and almost as resistant to compression as is steel.

Coupled with this terrific strength of the vertebrae is the natural elasticity and resiliency of the spinal column, plus the protection afforded by surrounding muscles and other soft tissues; all of these factors combine to provide the great resistance of the bony vertebra to absorb much direct and indirect violence without fracturing.

Periosteum—is the outer fibrous covering of the compact bone; it covers the entire surface of the vertebra except at the articular surfaces where it is replaced by articular cartilage.

The periosteum consists of two layers; the outer being dense connective tissue with blood vessels and nerves and few cells, while the inner is a loosely arranged network of white fibrous and yellow elastic fibers supporting fibroblasts and some osteoblasts. The inner layer is also known as the **cambium layer**. The blood vessels pass from the outer layer through the inner one to reach the Volkmann's canals and so enter the Haversian canals.

Periosteum has several important functions; it is concerned with nourishment of the bone by bringing to it the blood vessels, lymphatics, and nerves; it serves to give attachments to tendons and ligaments, and it provides a supply of osteoblasts to form new bone when needed.

Endosteum—is a thin connective tissue membrane which lines the cavities of bone, including the marrow cavities of spongy bone. It assists in the formation of new bone cells.

Marrow—Each vertebra contains two distinct types of bone marrow; red and yellow.

Red marrow is found in the spongy bone tissue of the vertebra. It consists of (1) a small amount of fibrous connective tissue that acts as a support for a large number of blood vessels (2) a large number of marrow cells or **myelocytes** (3) a small number of fat cells (4) a large number of developing red blood cells called erythroblasts, and (5) specialized cells known as **osteoclasts** which have to do with bone formation.

Yellow marrow is also found in the cavities of spongy bone as well as in the Haversian canals. It is made up of a fibrous connective tissue supporting numerous blood vessels and cells. However, most of its cellular content is fat cells with only a few myelocytes being present, and very few red blood cells.

Blood Vessels, Lymphatics and Nerves of the Vertebrae

(a) **Blood Vessels**—The blood vessels of bone are very numerous. Compact bone tissue is supplied by a dense network of arterioles arising from vessels extensively ramifying through the periosteum. Spongy bone is supplied in the same manner except that the vessels are larger and are distributed through the cavities of the spongy bone tissue. Most of the vessels enter by way of Volkmann's canals and either enter the Haversian canals of compact bone, or form networks in the cavities of spongy bone. The vertebral bodies also show one or more foramina for the passage of a large artery which corresponds to the typical nutrient artery of long bones, and these vessels added to the other extensive networks penetrate the entire bony substance to form intercommunicating channels carrying nutrients and other essential materials to every part of the vertebra.

Venous drainage is accomplished by an extensive network of thin-walled veins that have no valves: these pass out by the Haversian canals ultimately reaching the periosteum through the Volkmann's canals.

(b) **Lymphatics**—The outer layer of the periosteum contains relatively large lymphatic vessels, while lymph capillaries run with the blood vessels in the Haversian and Volkmann's canals. In addition, the lacunae and canaliculi make up a complete network of lymph channels which communicate with these lymph vessels.

(c) Nerves—are extensively distributed to the vertebrae. Both medullated and nonmedullated fibers accompany the blood vessels into the bone.

INDIVIDUAL VERTEBRAE OF THE SPINAL COLUMN

The spinal or vertebral column is made up of 33 vertebrae in a young person, but as age advances the number is reduced to 26 due to the consolidation of the five sacral segments into one sacrum and the uniting of the coccygeal segments into a single coccyx. The upper 24 vertebrae remain separate throughout life and are designated as the true or movable vertebrae; the lower two, or sacrum and coccyx, lose their mobility and are known as the false or fixed vertebrae.

The true vertebrae are counted as seven cervicals, twelve thoracic or dorsal, and five lumbars.

It is essential that the Chiropractor, and the Chiropractic student, know in intimate detail the anatomy of each of the 26 segments making up the spinal column. Such an understanding is necessary to fully comprehend the reasons for certain anatomical parts, as well as their actions and functions. Also, the attachments of the spinal ligaments and muscles are intricately arranged between descriptive parts of spinal segments and without adequate knowledge of the fundamental features of the vertebrae such studies of the spinal column become unusually difficult and complex.

Since the spinal column is the specific domain of the Chiropractor it behooves every member of the profession to know this part of human anatomy in complete detail.

As the spinal column of the living body is the working tool of the Chiropractor, so should a specimen of the column be considered an essential study-aid to give a deeper concept of the "big-idea"—that the Chiropractor is working through the spinal column to release an Innate Intelligence by way of a studied, scientific approach rather than a mechanical "setting of bones."

TYPICAL AND ATYPICAL VERTEBRAE

With certain exceptions, the true vertebrae present similar characteristics which classify them as typical vertebrae.

In order to be considered as a typical vertebra it is necessary that it possess the following descriptive parts: One body, two pedicles, two laminae, four articular processes, two transverse processes and one spinous process.

Because one or more of these descriptive parts may be lacking on a vertebra, or the vertebra may show certain features peculiar to that particular segment, such vertebrae are referred to as atypical or peculiar vertebrae.

Those listed as peculiar vertebrae include atlas, axis, seventh cervical, first, ninth, tenth, eleventh and twelfth dorsal, and the fifth lumbar. Of course the sacral and coccygeal vertebrae are also considered as peculiar.

Description of a typical vertebra

For purposes of study the fifth thoracic will serve very well as it possesses all the needed descriptive parts common to all typical vertebrae.

The fifth thoracic consists of two essential parts—the body anteriorly, and the vertebral or neural arch posteriorly.

These form a closed foramen, the vertebral foramen or neural ring, of which the body forms the anterior boundary and the neural arch forms the lateral and posterior limits.

The Neural Arch is formed by the two pedicles or roots and a pair of laminae, and supports seven processes—four articular, two transverse and one spinous.

When the vertebrae are articulated as in the living specimen the vertebral foramina or neural rings form the vertebral canal or spinal canal which contains the spinal cord and its meninges, the roots of the spinal nerves, the posterior longitudinal ligaments and the nerves, vessels, and lymphatics which supply these structures.

1. BODY (Corpus vertebra) is a short column of bone making up the largest part of a vertebra. Its superior and inferior surfaces are broad, flat, and rough for the attachment of the intervertebral discs; each surface also shows a slight rim around its circumference. Anteriorly, the body is slightly concave from above downward, and is definitely convex from side to side. The posterior surface is flat from above downward and slightly concave from side to side.

The arterial supply to the body enters from the anterior through several small nutrient foramina and the venous drainage leaves on the posterior surface.

The body of each typical dorsal vertebra presents two pairs of costal pits or demifacets for receiving the heads of the ribs to form the costovertebral articulations. The superior pair is located at the superior border of the body, above and antero-lateral to the pedicle; and the inferior pair is found on the inferior border of the body, below and antero-lateral to the pedicle.

The inferior pit of one vertebra approximates the superior pit of the vertebra next below and the two together with the intervening intervertebral disc form a complete socket to receive the head of a rib.

2. PEDICLES (Roots, or radices arci vertebrae) are two short thick columns of bone which project backwards from the posterior surface of the vertebral body. Each pedicle has a deep concavity on its upper and lower borders which are called the vertebral notches—and when two vertebrae are in juxtaposition the inferior notch of one and the superior notch of the other form an intervertebral foramen.

3. LAMINAE are two broad plates of bone arising from the pedicles and directed backwards and medialwards. They fuse in the median line posteriorly. Because the ligamentum flava bind together adjacent verterbrae at their laminae, these structures are roughened on their superior borders and anterior inferior surfaces which points correspond to the origins and insertions of these ligaments.

4. SPINOUS PROCESS. The spinous process of the typical dorsal vertebrae is long and roughly triangular in cross section. It runs backwards and downwards from the junction of the laminae and on its free end exhibits a small tubercle. The spinous serves for attachment of muscles and ligaments.

5. TRANSVERSE PROCESSES. The transverse processes are two in number and extend laterally and backwards from the arch at the junction of the pedicles and laminae. They are thick and strong and serve as points of attachment for muscles and ligaments of the spinal column. The typical thoracic vertebra exhibits a small concave surface on the anterior surface of each transverse for articulation with the tubercle of a rib.

6. ARTICULAR PROCESSES. On each thoracic vertebra there are two superior and two inferior articular processes, arising from the junction of the pedicles and laminae.

The superior processes present flattened superior articular surfaces which are directed upwards and slightly backwards; the articular surfaces of the inferior processes are concave and are directed downwards, forwards and medially.

DESCRIPTION OF INDIVIDUAL VERTEBRAE

The Occiput (Occipital Bone)

A detailed description of the occiput merits a position among the studies of the individual vertebrae of the spinal column because of its part in the atlanto-occipital articulation; the modern Chiropractor should be as conversant with this important bone as he is with the atlas and other vertebrae.

Location: the occiput is placed at the back and lower part of the cranium. It is roughly trapizoid in shape, and consists of four parts arranged around the foramen magnum, a large oval opening through which the vertebral canal communicates with the cranial cavity.

Parts—The four parts are: (1) Basilar, anterior to foramen magnum, (2) Squamous, behind and above the foramen, (3) and (4) are the two Lateral Parts or Condylar Parts, one on either side of the foramen magnum.

(1) Basilar Part—is fused anteriorly with the body of the sphenoid bone, and on each side its margin articulates with the petrous portion of the temporal bone. It is quadrilateral in shape and projects upward and forward from the foramen magnum. The upper or superior surface of the basilar part presents a shallow groove which supports the medulla oblongata of the brain and gives attachment to the tectorial membrane.

The inferior surface shows a small pharyngeal tubercle for the attachment of certain pharyngeal muscles, and in addition there are several small roughened areas for the attachment of anterior spinal muscles and the anterior atlanto-occipital ligament.

(2) Squamous Part located above and behind the foramen magnum is curved from side to side and from above down-

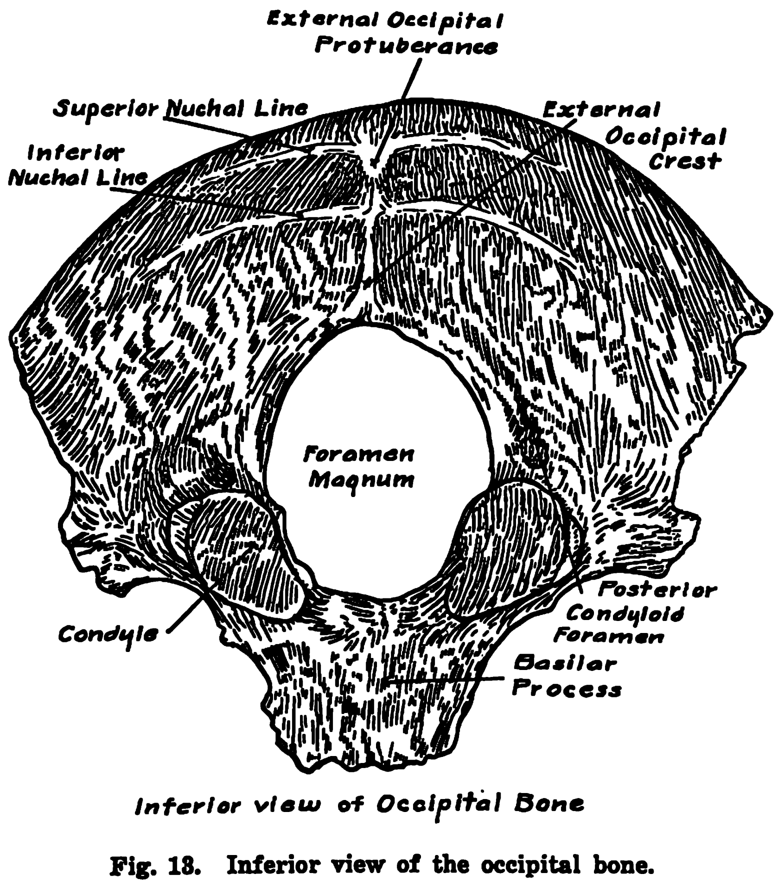


Fig. 13. Inferior view of the occipital bone.

ward. On each side the upper part of its margin articulates with the parietal bone and the lower part with the mastoid portion of the temporal bone.

For purposes of study the squamous part presents an external and an internal surface.

1. **The External Surface** is irregular and convex, and presents the **External Occipital Protuberance**—a prominent tubercle located midway between the foramen magnum and the superior margin of the occiput. Extending back and down from the external occipital protuberance is a median ridge or crest of bone called the **External Occipital Crest** or the **Median Nuchal Line** which along with the protuberance gives attachment to the ligamentum nuchae.

Arising from the external occipital protuberance is a curved ridge, the **Superior Nuchal Line**, which extends lateralward to the lateral margin of the occiput. Above this line and running nearly parallel to it is a second less distinctly marked ridge—the **Highest Nuchal Line.** That part of the squamous portion of the occiput lying above the superior nuchal line is known as the **planum occipitale**, and the area below the line is the **planum nuchale.**

About midway between the superior nuchal line and the posterior margin of the foramen magnum a third occipital line, the **Inferior Nuchal Line**, arises from the middle of the occipital crest and extends laterally to the jugular process. The inferior nuchal line divides the planum nuchal into two superior and two inferior nuchal areas.

The nuchal lines and other bony projections and their intervening surfaces are designed for the attachment of muscles. With the exception of the highest nuchal line which gives origin to part of the occipitales muscle, the other surfaces give attachment to spinal muscles.

The superior nuchal line gives origin to the Trapezius and insertion to Sternocleidomastoideus and Splenius Capitis; into the area between the superior and inferior nuchal lines (superior nuchal area) the semispinalis capitis and the obliquis capitis superior are inserted, while the inferior nuchal area receives the insertions of the rectus capitis posticus major and minor.

Chiropractic terminology frequently refers to the superior and inferior nuchal lines as the **superior** and **inferior** curved lines.

2. **The Internal Surface** of the squamous is deeply concave and shows two grooved ridges that cross each other to form four fossae; the upper two, triangular in form, lodge the occipital lobes of the cerebrum whereas the lower two quadrilateral fossa receive the lobes of the cerebellum.

At the point of intersection of the two ridges is the **Cruciate Eminence** the center of which supports the **Internal Occipital Protuberance**; and extending from the protuberance to the posterior margin of the foramen magnum is the **Internal Occipital Ridge** for the attachment of the falx cerebelli.

Situated to one or the other side (usually the right side) of the internal occipital protuberance is a wide depression formed to receive the junction of the superior sagital and transverse blood sinuses, which union is named the **confluence of the sinuses** or **torcular herophili.**

(3) and (4) **Lateral, or Condylar Parts**—form the lateral margins of the foramen magnum and located on their inferior surfaces are the **Occipital Condyles** which articulate with the lateral masses of the atlas.

The two **occipital condyles** are usually oval, convex, knuckle-like processes of bone which tend to converge anteriorly, and are slightly everted. Their posterior borders are on a line with the center of the foramen magnum. The articular surfaces of the condyles are smooth and covered with articular cartilage; but their circumferential borders are roughened for the attachment of the atlanto-occipital capsular ligaments. On the medial side of each condyle is a rough tubercle for the insertion of the check or alar ligaments of the occipito-axial joint.

Above and medial to each condyle is a small, short canal, the **Hypoglossal Canal** which opens by the **anterior condyloid foramen** into the cranium and transmits the hypoglossal nerve and part of the posterior meningeal artery.

Behind either condyle is a depression, the **condyloid fossa (Condylar Fossa)** which receives the posterior superior edge of the atlas lateral mass when the head is bent far backward.

Running laterally from the condyles is a projection of bone called the **Jugular Process** which articulates with the petrous

portion of the temporal bone. The anterior border of the jugular process shows a deep notch which forms the posterior boundary of the jugular foramen. The glossopharyngeal, vagus and spinal accessory nerves are among the important structures leaving the cranium via the jugular foramen.

THE TYPICAL CERVICAL VERTEBRAE

The typical cervical vertebrae possess three characteristic features (1) small size (2) irregular outline (3) three foramina. The atlas, axis, and seventh cervical present certain peculiar features which necessitates a separate description for each.

The following characteristics are common to the third to the sixth cervical inclusive:

Body—The body is small and oval but is wide transversely. The anterior and posterior surfaces are flat and of the same height; but the anterior surface is slightly below the horizontal plane of the posterior, and its inferior border is prolonged downward to over-lap the superior and anterior part of the vertebral body next below.

The superior surface of the body is concave from side to side and is raised into prominent lips along the lateral and posterior margins while the anterior margin tends to slope to the inferior.

The inferior surface is concave from anterior to posterior, convex from side to side, and shows shallow concavities along its lateral margins to receive the lips of the adjacent vertebra.

The partial interlocking of these surfaces common to the cervical bodies helps to stabilize these intervertebral articulations.

Pedicles—The pedicles or roots are short and rounded. They spring from the postero-lateral surface of the body midway between its upper and lower borders and are directed backwards and sidewards. The superior and the inferior vertebral notches are of equal depth but the superior notch is slightly the narrower of the two.

Laminae—are long, narrow, slender and sloping.

Spinous Process—is short and bifid at its free extremity. Oftentimes the two halves of the bifurcation are not of the same size or shape.

Tranverse Process—The paired transverses of each of the upper six cervicals are pierced by the **foramina transversaria** which convey the vertebral arteries and veins and associated vertebral plexuses of nerves. Each foramen transversarium is bounded by the side of the body, the pedicle, and the two parts of the transverse process.

Each transverse process extends sidewards and slightly forwards and downwards. It has two parts:

(1) **Posterior part,** or the **true transverse process,** arises from the vertebral arch,

(2) **Anterior part,** or **costal process** arises from the side of the body. It is called the costal process because it corresponds to a rib in the thoracic region.

The anterior and posterior parts of the transverse process are united laterally by the **costo-transverse lamella** which is projected still further laterally to form the free extremity which is bifid and presents an anterior and a posterior tubercle. The costo-transverse lamella is grooved on its upper surface to support the anterior primary division of a cervical nerve.

The anterior tubercle of the sixth cervical is sometimes enlarged, and is then called the **Carotid Tubercle** as the common carotid artery can be compressed against it.

Vertebral Foramen is larger than in thoracic or lumbar region and is roughly triangular in shape with rounded edges. Its large size is adaptative to the cervical enlargement of the contained spinal cord and to the greater motion of the cervical region.

The vertebral foramen plus the two foramina transversaria of each cervical vertebra form the three foramina characteristic of a cervical vertebra.

The Articular Processes—are four in number, two superior and two inferior, and are situated at the junction of the pedicle with the lamina. The **articular facet** of each process is flat and nearly circular. The articular surfaces of the superior pair look upwards and backwards, whereas the articulating surfaces of the inferior pair look downwards and forwards.

Chiropractic anatomy has widely adopted the term **Zygapophyses** when speaking of the articular processes. The superior

Fig. 14. Anterior view, cervical region.

Fig. 15. Posterior view, cervical region.

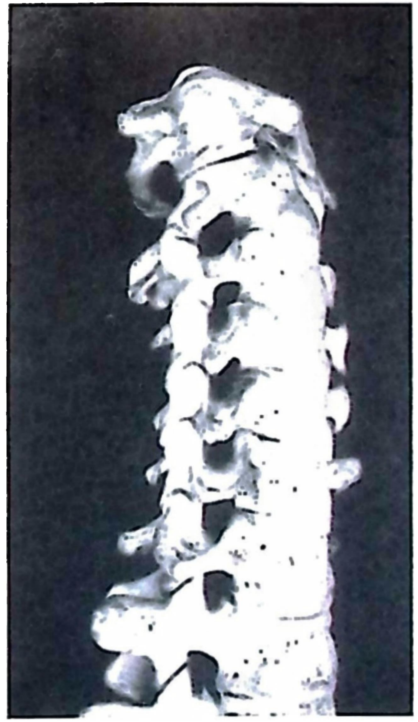


Fig. 16. Oblique view, cervical region.

processes are referred to as the **pre-zygapophyses**, and the inferior processes, the **post-zygapophyses**. The terms are correctly used as a zygapophysis is a "yolking" process which well describes the action of these articulations to help lock the cervical vertebrae together as well as to limit their range of motion.

Although the typical cervical vertebrae—third, fourth, fifth and sixth—are very similar in appearance it is possible to distinguish one from the other.

In the third and fourth the costo-transverse lamella is oblique, being more oblique in the third than in the fourth.

The third is considered the smallest vertebra in the spinal column, nevertheless the lateral depth of its body is greater than the fourth. The costo-transverse lamellae are horizontal in the fifth and sixth, and the sixth often has an enlargement on its transverse process—"the carotid tubercle."

PECULIAR CERVICAL VERTEBRAE

The third cervical vertebra to the sixth cervical inclusive are considered as typical cervical vertebrae as they each have all the descriptive parts commonly ascribed to a cervical vertebra.

However there are three vertebrae of this region which do not present all the features of a typical cervical, and accordingly they are classed as Peculiar or Atypical.

The peculiar cervical vertebrae are:

1. Atlas, 2. Axis, 3. Seventh Cervical.

ATLAS—or the first vertebra, has no body and no spinous process; therefore, it lacks lips and a bifid spinous process. The body of the atlas has fused with the axis to form the odontoid process in the early embryological development of the spinal column.

The atlas is so named because it supports the globe-like head. It takes the shape of a complete bony ring and consists of a pair of thick, symmetrical **lateral masses** united by the **anterior** and **posterior arches**.

The descriptive parts of the Atlas are:

1. Two lateral masses

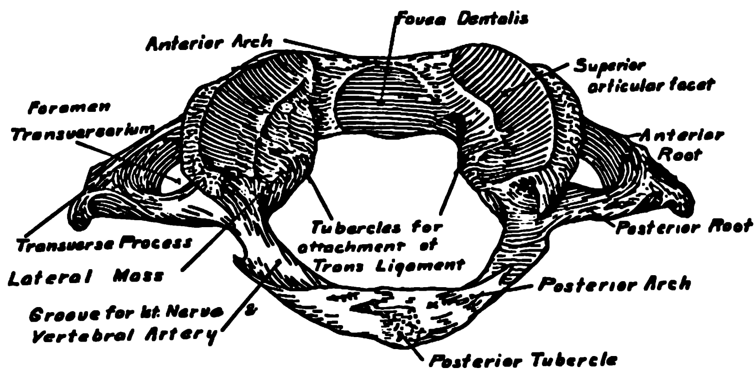


Fig. 17. Atlas—posterior superior view.

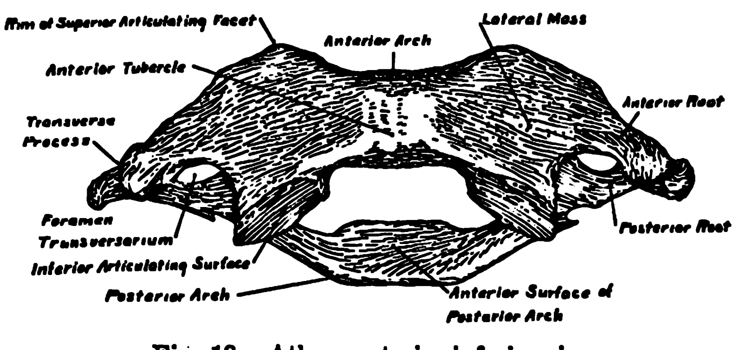


Fig. 18. Atlas—anterior inferior view.

2. Four articular facets

3. One anterior arch

4. One posterior arch

5. Two transverse processes

1. **Two Lateral Masses**—are thick, strong, and are the most bulky parts of the atlas to support the weight of the head. Each mass is so placed that it converges anteriorly and diverges posteriorly; in relation to the total circumference of the atlas ring each forms about one-fifth of the circumference.

The anterior surfaces of the two lateral masses are joined to the anterior arch, and the posterior surfaces attach to the posterior arch.

The external surface gives origin to the transverse processes.

The internal surface of each lateral mass is rather rough and irregular and presents a small tubercle for the attachment of the transverse atlantal ligament. This ligament stretches across the ring of the atlas and divides it into two unequal parts; the smaller anterior part is occupied by the odontoid process of the axis, the larger posterior portion transmits the spinal cord and its membranes. The posterior division is called the neural ring of the atlas and is bounded by the transverse ligament in front and the posterior arch on the sides and behind.

2. **Four Articular Facets**—Each lateral mass shows a superior and an inferior articular facet or articular pit on its corresponding surface.

The superior facets are elongated and deeply concave to articulate with the occipital condyles. They are oval in shape and converge anteriorly in order to fit the contour of the condyles; but to the posterior they tend to diverge. Because of these cup-like articulating surfaces in contact with the condyles of the occiput a nodding movement of the head is made possible.

The inferior facets are circular in form and articulate with the superior surfaces of the second cervical vertebra. Each inferior facet is somewhat flattened or slightly concave and is directed downward and medialward; by their articulations with the axis below a type of joint is formed which helps permit the rotatory movement of the head. The inferior articular facets of atlas are situated anterior to the intervertebral foramina at this level.

3. **One Anterior Arch**—The anterior arch joins the lateral masses at the anterior and makes up about one-fifth of the total circumference of the atlas ring. Its anterior surface is convex and presents an **Anterior Tubercle** at its center for the attachment of certain anterior spinal muscles and ligaments. Its posterior surface is concave and in the center of this surface is a deep circular concavity known as the **Fovea Dentalis** or **Fovea Dentis** for articulation with the odontoid process of axis.

The upper and lower borders of the anterior arch give attachment to the anterior atlanto-occipital ligament above, and to the anterior atlanto-axial ligament below.

4. **One Posterior Arch**—The posterior arch unites the lateral masses posteriorly and forms about two-fifths of the atlas ring circumference. In its median line the posterior arch presents a small rough **Posterior Tubercle** which represents a rudimentary spinous process.

The posterior arch, at its junction with a lateral mass, presents on its superior surface a steep groove representative of the superior cervical notch and known as the **groove for the vertebral artery** which it transmits along with the first spinal (suboccipital) nerve.

This groove is not infrequently converted into a foramen by a thin plate of bone growing backwards and downwards from a small tubercle on the back of the lateral mass.

The inferior surface of the posterior arch directly behind the lateral masses shows two shallow grooves—the **inferior vertebral notches**, which with the superior vertebral notches of the axis vertebra form intervertebral foramina for the exit of the second pair of spinal nerves.

The superior and inferior surfaces of the posterior arch give attachments to ligaments uniting the atlas to the occipital bone and the axis.

The posterior tubercle gives origin to the right and left rectus capitis posterior minor muscles.

5. **Two Transverse Processes**—The transverse processes are large and extend farther laterally than do those of the other cervical vertebrae with the possible exception of the seventh. They project slightly downwards as they run laterally from a

lateral mass and are somewhat flattened on their superior and inferior surfaces.

Each transverse process is pierced by a foramen transversarium which is directed from below, upward, and backward. The free end of the transverse is broad and rough and is usually not bifid due to complete fusion of the anterior and posterior tubercles into a single solid mass lateral to the foramen transversarium. Each transverse process gives attachment to muscles which assist in rotating the head such as rectus capitis lateralis, obliquis capitis superior and inferior, levator scapulae, scalenus medius and splenius cervicis.

AXIS OR EPISTROPHEUS (The second cervical vertebra)

The axis is the strongest and thickest of all the cervical vertebrae and is so named because it forms a pivot upon which the atlas and the head rotate. Its most outstanding feature is the tooth-like ODONTOID PROCESS or DENS that stands up from the upper surface of its body.

The descriptive parts of the axis include:

1. **Body**
2. **Odontoid process**
3. **Four articular surfaces**
4. **Two pedicles**
5. **Two laminae**
6. **Two transverse processes**
7. **One spinous process**

1. **Body**—The body, or centrum, is thicker at the anterior than at the posterior and its anterior border is prolonged downward as a lip which overlaps the upper and front part of the third cervical body. The anterior surface of the axis body exhibits a longitudinal ridge in the median line which separates two shallow concavities for the attachment of the Longus colli muscles. The posterior surface of the body is flat from above downward but is slightly concave in the transverse direction.

The superior surface of the body presents the odontoid process and the superior articular surfaces, with the inferior body surface supporting the inferior articulating surfaces.

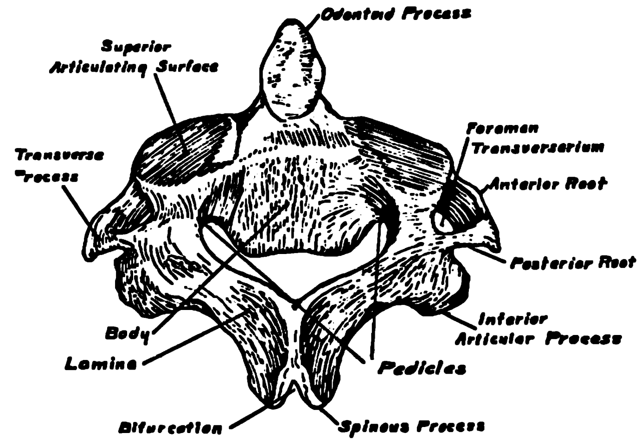


Fig. 19. Axis—posterior superior view.

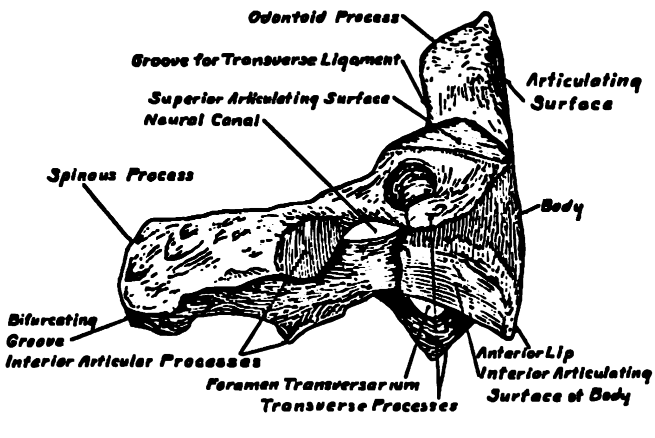


Fig. 20. Axis—lateral inferior view.

2. Odontoid Process—The odontoid process, or dens, shows a slight constriction or neck where it joins the axis body. The front of the odontoid has an oval facet which receives the corresponding facet, fovea dentalis, of the anterior arch of the atlas. The back of the odontoid is grooved to receive the transverse ligament of the atlas. The apex is somewhat pointed and gives attachment to the middle odontoid or apical dental ligament, and directly below the apex there are two lateral enlargements for the attachment of the alar or lateral odontoid ligaments; these three odontoid ligaments connect the odontoid process to the occipital bone. The odontoid has a thicker outside layer of compact bone than does the remainder of the axis.

3. Four Articular Surfaces—Two superior and two inferior. The superior articulating surfaces articulate with the inferior articular surfaces of the atlas lateral masses above, and through them the weight of the head is transmitted to the spinal column.

They are nearly circular, slightly convex, and are directed upward and lateralward. Each is supported on a part of the axis body, pedicle, and anterior root of a transverse process; to the inferior each surface is grooved by the medial surface of the adjacent foramen transversarium. Behind each surface is a groove for the passage of the second cervical nerve; only the 1st and 2nd pairs of spinal nerves emit posterior to the articular surfaces; all the others leave anterior to the articular surfaces.

The inferior articular surfaces resemble in form and position those of the subjacent cervical vertebrae.

4. Two Pedicles—are thick and strong and are partially hidden beneath the superior articular surfaces. The pedicles arise from the sides of the body and the odontoid process and project backwards and slightly outwards. On their superior surfaces each pedicle presents a broad groove or superior vertebral notch which with the atlas above completes the first intervertebral foramen transmitting the second cervical nerve. On each inferior surface of the pedicle is located a deeply grooved inferior vertebral notch which helps form part of the second intervertebral foramen giving passage to the 3rd cervical nerve on each side.

5. Two Laminae—proceeding backwards from the pedicles are the laminae; two strong, thick, prismatic plates of bone which

converge and fuse in the median line to give rise to the spinous process.

6. **Spinous Process**—The spinous process of axis is broad, large, and very strong, with a bifid tubercle-like free extremity. It has a deep concavity on its inferior surface representing the space between the two prongs of its bifurcation. Since this space corresponds to the median line of the vertebral body it is used as a landmark in vertebral palpation rather than the bulk of the spinous process proper which may give a misleading chiropractic analysis because of the many variables of the prongs. Normally the spinous process of axis can be palpated about two inches below the external occipital protuberance.

7. **Two Transverse Processes**—The transverse processes are small and show no grooves nor bifurcations. They turn downwards and backwards. The anterior root of the transverse arises from the upper and outer border of the axis body and projects downward, outward and backward. The posterior root arises at the junction of the pedicle and lamina and then runs downward, outward and forward to join the anterior root thus enclosing the foramen transversarium. The transverse foramen is directed upwards and laterally at a very oblique angle.

The Occipito-Atlanto-Axial Complex—

In such vertebrate forms as fishes the head and the trunk move as one unit because of the single occipital condyle articulating firmly and rigidly with the first segment of the spinal column. With such an arrangement motion of the head and neck is extremely limited. Frogs and certain other amphibians have two occipital condyles with a corresponding pair of articular surfaces on the first vertebra which allows the head to swing up and down in hinge fashion but permits of little lateral movement. However, in all mammals there are two occipital condyles articulating with paired lateral masses of the atlas; in addition there is an axis vertebra supporting an odontoid process around which the anterior part of the atlas can rotate. The joints between these three segments known as the occipito-atlanto-axial complex allow the head to move upward or backward and downward or forward on the atlas with lateral rotation of the head made possible by the pivoting of the atlas on the axis.

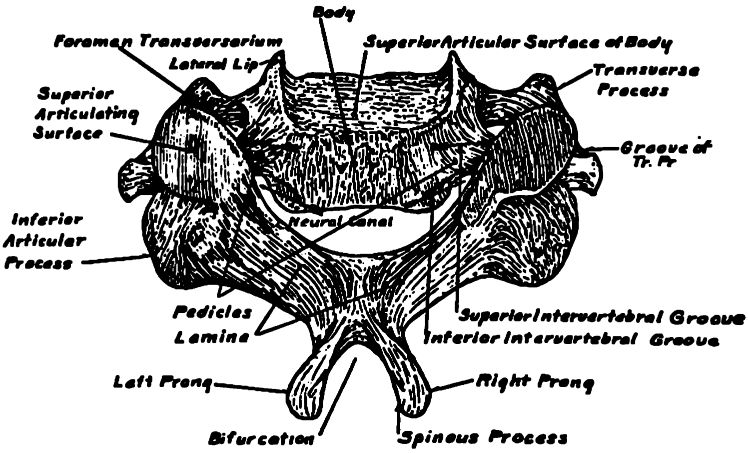


Fig. 21. Posterior superior view of fourth cervical—a typical cervical.

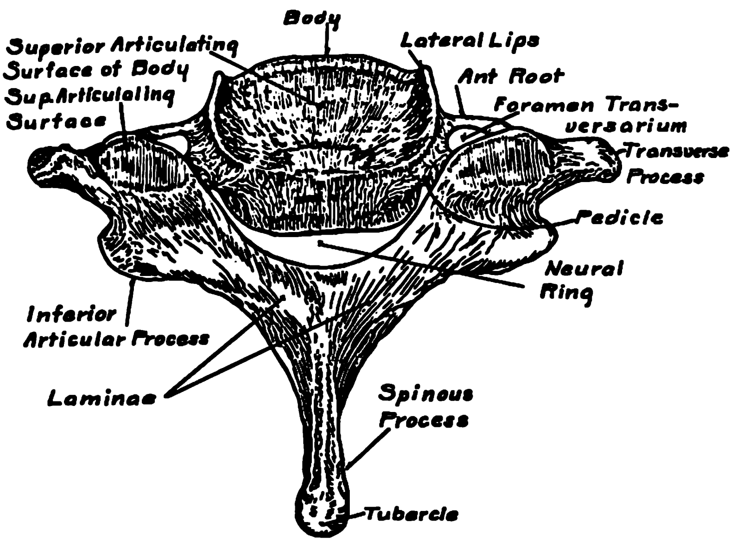


Fig. 22. Posterior superior view of seventh cervical—a peculiar cervical.

SEVENTH CERVICAL

1. The Spinous Process

The seventh cervical vertebra is also known as the **vertebra prominens** because of its long and slender spinous process. This process is usually longer than that of any cervical vertebra, it is thick and nearly horizontal in direction, and is not bifid but rather it presents a tubercle on its free extremity for the attachment of the ligamentum nuchae. This deviation from a normal bifid spinous process is the major reason for classifying the seventh cervical as a peculiar vertebra. In addition it is considered as a transitional vertebra because it assumes some of the characteristic features of both cervical and thoracic vertebrae; lying as it does at the junction of the cervical and thoracic regions this transition naturally follows. Occasionally the seventh cervical spinous process shows a definite bifurcation, but this is rare.

Although the seventh cervical vertebra is commonly known as vertebra prominens because its spinous protrudes farther backwards than those of the other cervicals this is not so in all cases. In fact, only 60 per cent of seventh cervical vertebrae can be placed in this category, the remaining 40 per cent being made up of cases in which the spinous process of the sixth cervical projects farthest backward and so would be considered vertebra prominens instead of the seventh cervical.

2. Seventh Cervical Body

The superior surface of the body of the seventh cervical is typical of the cervical vertebrae and the inferior body surface is characteristic of the thoracic vertebral bodies. The superior surface is concave and supports two lateral lips which project upwards to articulate with the inferior surfaces of the sixth cervical body. The inferior surface of the body is somewhat flattened and there is no anterior lip on the anterior-inferior margin nor are there depressions on the lateral-inferior margins.

3. Articular Processes

The articular processes are more nearly perpendicular than those of the other cervicals but slightly less so than the thoracic articular processes.

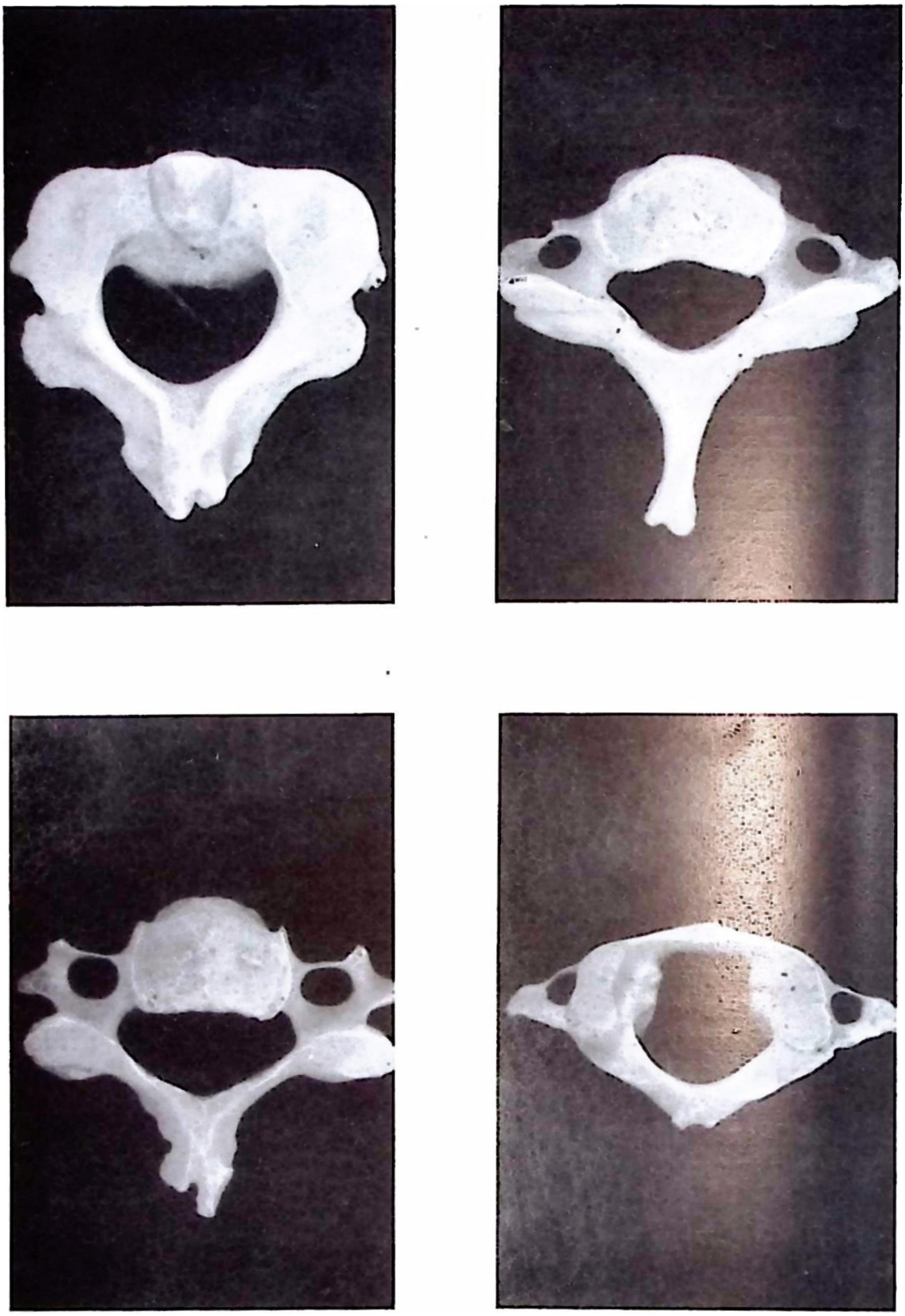


Fig. 23. The atlas, axis, 4th cervical and 7th cervical are shown above. Identify each and list all the descriptive parts of each.

4. Transverse Processes

Each transverse process is large and broad and ends in a blunt extremity. The anterior root is smaller and shorter than those of the other cervical vertebrae but the posterior root is larger and projects more towards the posterior than do the posterior roots of the other cervicals. The foramen transversarium formed by the two roots is quite small and may transmit the corresponding vertebral vein but more frequently both the vertebral artery and vein pass in front of the transverse process and not through the foramen. The anterior root occasionally overdevelops as a cervical rib which anomaly is dealt with fully in the chapter on cervical anomalies.

The foregoing variations in the spinous process, the body, the articular processes, and the transverse processes are the reasons for considering the seventh cervical an atypical or peculiar cervical vertebra.

THORACIC VERTEBRAE

The thoracic or dorsal region of the spinal column is that part to which the ribs of the thorax are attached. Normally, there are twelve thoracic vertebrae, but this number is occasionally increased or decreased by one vertebra and corresponding pair of ribs. These vertebrae support the ribs directly, and the sternum indirectly, as well as forming the posterior median boundary of the thoracic cavity. Other functions include the protection of the thoracic viscera, providing attachment for many muscles and ligaments, and supporting the weight of the trunk. The thoracic vertebrae are intermediate in size between those of the cervical and lumbar regions; they increase in size from above downward with the lower thoracic group being much larger than the upper group.

Special Characteristics

Thoracic vertebrae, in addition to the usual descriptive parts, show the following special characteristics:

1. Facets on the sides of the bodies for articulation with the heads of ribs.
2. Facets on most transverse processes for articulation with the tubercles of the ribs.

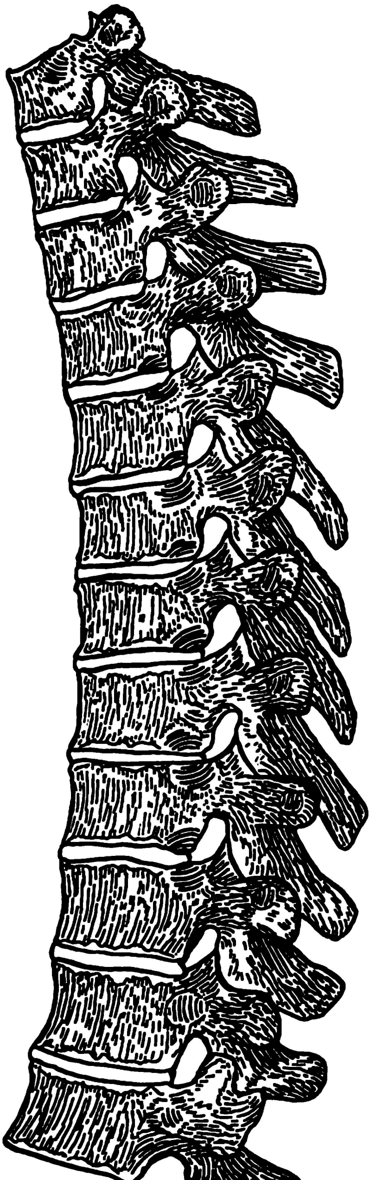


Fig. 24. Thoracic Region—
lateral view.

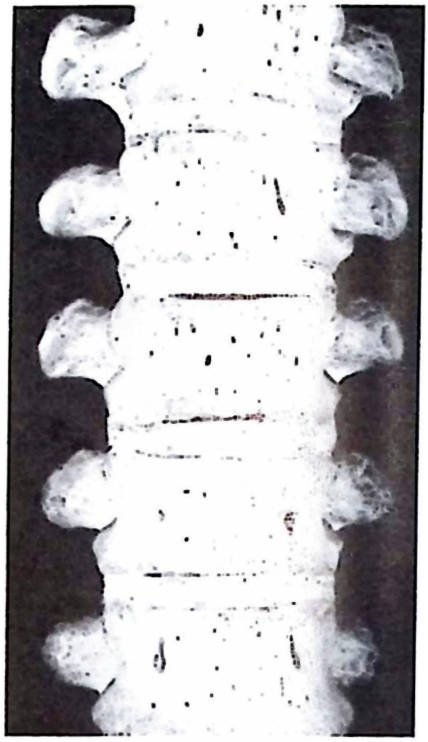


Fig. 25. Mid-thoracic vertebrae—
anterior view.

3. Each thoracic vertebra articulates with the pair of ribs with which it corresponds numerically, and the bodies of the upper eight or nine vertebrae articulate with a pair of ribs below as well.

TYPICAL THORACIC VERTEBRAE

The typical thoracic or dorsal vertebrae include the second through the eighth inclusive. They are considered as being typical because all possess the same descriptive parts and are similar in appearance except for size. The descriptive parts of a typical thoracic vertebra are:

1. Body—with its costo-vertebral articulating surfaces.
2. Pedicles.
3. Laminae.
4. Spinous process.
5. Transverse processes.
6. Vertebral foramen.
7. Articular processes.

1. Body—with its costo-vertebral articulating surfaces. The body is heart shaped when viewed from above or below, and in the mid dorsal region is as broad in the transverse direction as in the anterior-posterior direction. Each is deeper behind than in front. The superior and inferior surfaces of the body are flat in their centers, but around the circumference of each lateral margin is a ring of bone which forms a slight concavity to receive the convexity of the intervertebral disc. The anterior body surface is convex from side to side, and the posterior surface of the body is deeply concave.

The body of each typical thoracic vertebra supports two pairs of costo-vertebral articulating surfaces called costal facets which are actually demi-facets, or half-facets, as each individually provides only half an articulating surface for the head of a rib.

The superior pair of demi-facets are located near the roots of the pedicles, and the inferior pair arises from the body in front of the inferior vertebral notch. Each demi-facet is covered with

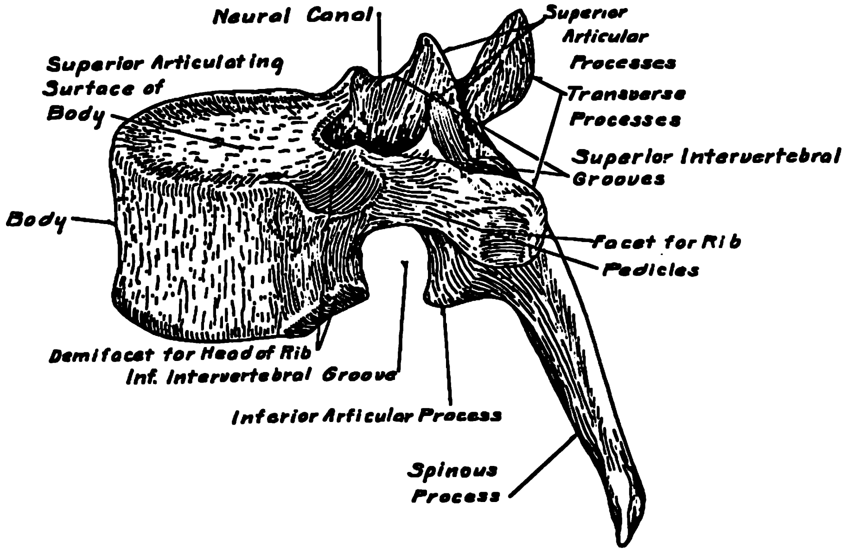


Fig. 26. A typical thoracic vertebra (6th).

articular cartilage, and in combination with a corresponding demi-facet above or below, and an intervening intervertebral disc, forms an oval articulating surface for the reception of the head of a rib.

2. **Two Pedicles**—are short, and directed backward and slightly upward. They support the inferior vertebral notches which are larger and deeper here than in any other of the spinal regions.

3. **Two Laminae**—are short, broad, and thick, and tend to overlap those of subjacent vertebrae.

4. **One Spinous Process**—is long, slender, and triangular on cross-section; in the mid-dorsal region from the 5th to the 8th, they tend to overlap and are directed obliquely downward, but above and below this level, they project backwards more horizontally.

5. **Two Transverse Processes**—arise from the arch behind the superior articular processes and pedicles. They are thick and strong, and relatively long, being directed obliquely backward and lateralward. The free end of each is expanded and bears on its anterior surface a small concave facet for articulation with the tubercle of a rib of corresponding number.

6. **The Vertebral Foramen**—is nearly circular, and is comparatively small because of the smaller diameter of the contained spinal cord in this region.

7. **Articular Processes**—two superior and two inferior. The superior pair arise from the junctions of the pedicles and laminae, and project upwards and laterally and slightly backwards; their articular surfaces are flat.

The inferior processes arise from the laminae and face downwards, medially and forward; and their articulation surfaces are also flat.

The articulation of the inferior articular processes of a thoracic vertebra with the superior pair of the vertebra next below, permits the gliding motion of this region in flexion and extension of the spinal column.

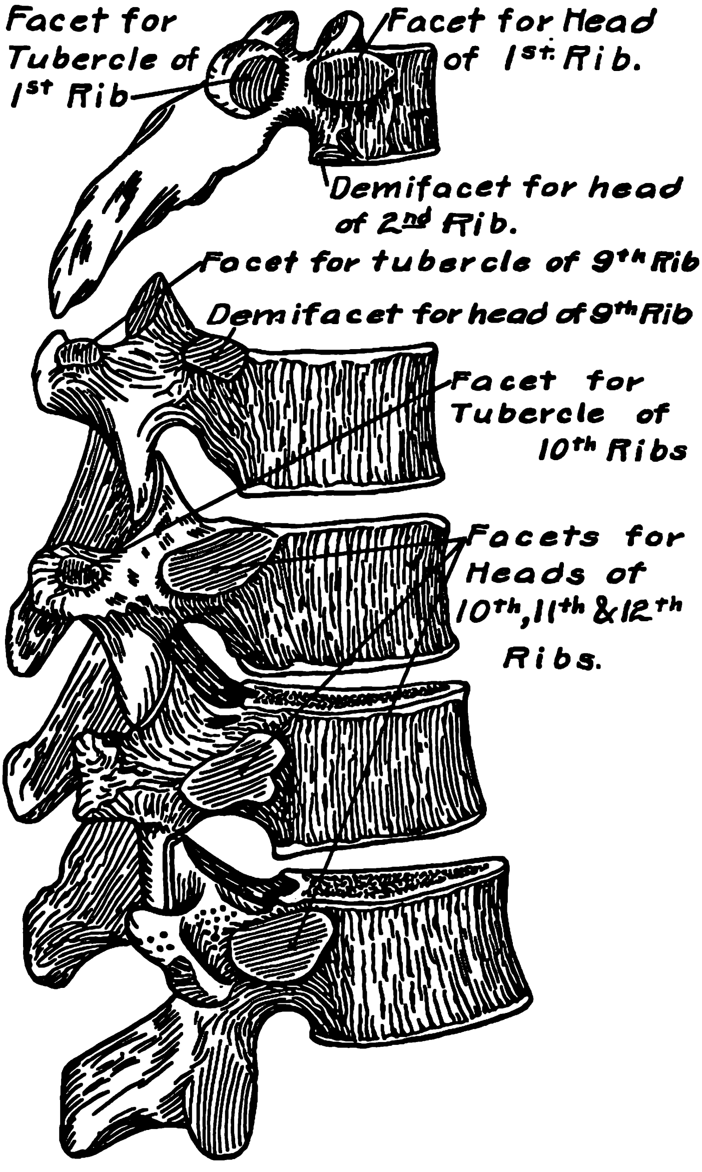


Fig. 27. Peculiar thoracic vertebrae.

PECULIAR OR ATYPICAL THORACIC VERTEBRAE

The first, ninth, tenth, eleventh, and twelfth thoracic vertebrae present certain peculiarities which differ from those of the typical thoracic, and thus they are specially considered.

The First Thoracic Vertebra—Its body resembles that of the 7th cervical in outline, being broad transversely and presenting a concave upper surface with lips on either lateral border. Also, on either side of the body is a complete articular facet for the head of the first rib, as well as a demi-facet for the upper half of the head of the second rib—thus, each side of the first thoracic body supports one and a half costal facets.

The superior articular processes are directed backward and upward. The spinous process is thick, nearly horizontal, and long, so that it may be even more prominent than the seventh cervical.

The transverse processes are long and show deeper superior vertebral notches than do any of the other thoracic vertebrae.

The Ninth Thoracic Vertebra—may show several variables in its costal facets. It may have no demi-facets below; it may have two demi-facets on either side, and when this occurs, the tenth thoracic has only demi-facets on its upper part.

The Tenth Thoracic Vertebra—has one complete costal facet on either side of the body and it is placed partly on the lateral surface of the pedicle. The tenth can be recognized by the facet on its transverse process for articulation with the tubercle of the rib.

The Eleventh Thoracic Vertebra—also has complete costal facets on either side of the body, but unlike the tenth, it has no facets on its transverse process for the tubercles of the eleventh ribs.

The body of the eleventh approaches the lumbar bodies in size and shape. The spinous process is short and nearly horizontal in direction. The eleventh thoracic can be distinguished from the twelfth by its inferior articular processes which project upward and lateralward, and backward, whereas those of the twelfth run forward.

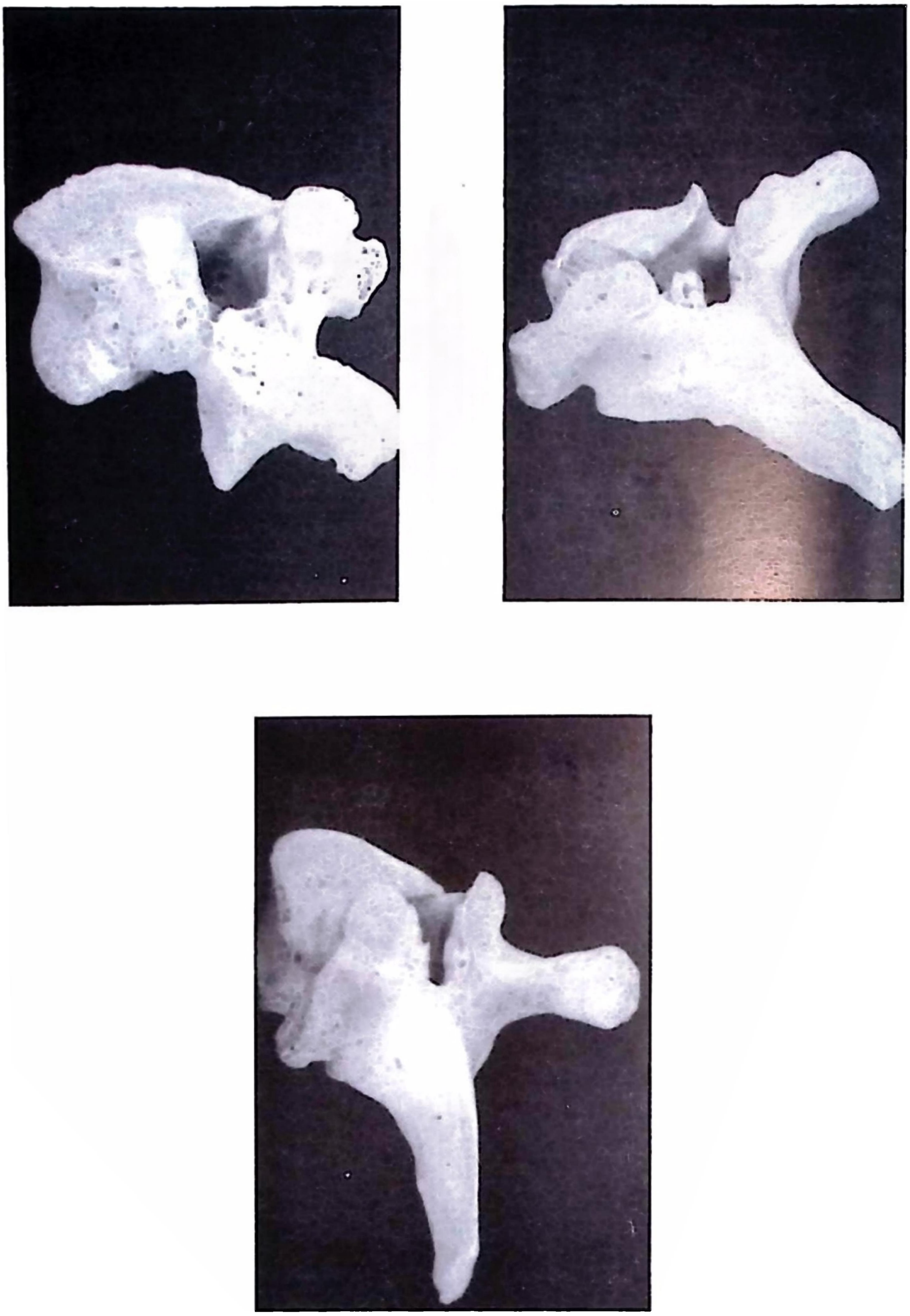


Fig. 28. The 1st, 5th and 12th thoracic vertebrae are shown above. Identify each, and list the important features of each one.

The Twelfth Thoracic Vertebra—resembles a lumbar vertebra, and can be properly termed a transitional vertebra showing as it does a similarity to the body, laminae and spinous process features of a lumbar, while still retaining some of the features of the thoracic group. Its body supports a pair of complete facets for articulation with the twelfth pair of ribs. The twelfth has transverse processes replaced by the superior, inferior, and lateral tubercles. The superior and inferior tubercles correspond to the mamillary and accessory processes of the lumbar vertebrae; the lateral tubercles are homologous with the small part of the lumbar transverse processes.

The inferior articular surfaces of the twelfth are convex, and directed sidewards and forward like those of a lumbar vertebra.

THORACIC VERTEBRAE AND RIB ATTACHMENTS

Although the spinal column is the main skeletal structure upon which the axial muscles act, the thoracic region of the human body shows specialized structures called ribs which afford attachment for muscles connecting with the vertebrae, and thus render the muscular effort more effective. Because of their importance in the action of certain spinal muscles and their connections with the thoracic vertebrae, the costal-vertebral joints may be properly considered in the anatomy of the thoracic region.

Motion in the thoracic region of the spinal column is actually hindered by the attachment of the ribs, with flexion and extension being quite limited, and lateral flexion is possible to only a slightly greater degree as the ribs are brought together on one side and spread somewhat on the other. Nevertheless, the attachment of many of the spinal muscles to the ribs affords leverage for movements of the spinal column as a whole.

The normal thoracic wall includes twelve pairs of ribs. The majority of the ribs articulate with the body and the transverse processes of their corresponding vertebrae, and thus may be divided into two sets, one connecting the heads of the ribs with the bodies of the vertebrae, another uniting the necks and tubercles of the ribs with the transverse processes. Both together are known as the **costo vertebral articulations.**

1. Articulations of the Heads of the Ribs, or Costo-Central Articulations—are classified as freely movable, arthrodial or gliding joints. They are formed by the articulations of the head of a rib and the facets on the bodies of two adjacent thoracic vertebrae with the intervertebral disc between them. The first, tenth, eleventh and twelfth ribs each articulates with a single vertebra.

The ligaments of a costo-central joint are:

a. The Articular Capsule

b. The Radiate

c. The Interarticular.

(a) **The Articular Capsule** is attached to the margins of the articulating surfaces. It is composed of short, strong fibers and is strongest at the upper and lower parts of the articulation. Above, some of its fibers pass through the intervertebral foramen to the back of the intervertebral disc, while its lower fibers are continuous with the ligament of the neck of the rib.

(b) **The Radiate Ligament, or Stellate Ligament, or Anterior Costovertebral Ligament,** is the thickened anterior part of the capsule. It radiates in three bands from the anterior surface of the head of the rib. The superior band or fasciculus ascends to the body of the vertebra above, the inferior fasciculus descends to the body of the vertebra below and the middle fasciculus passes horizontally to the intervertebral disc. As regards the first rib the fibers of the radiate ligament pass upwards to the body of the seventh cervical vertebra as well as to that of the first thoracic. In the articulations between the ribs and the tenth, eleventh, and twelfth thoracic vertebrae, the radiate ligaments attach to the body of the vertebra next above as well as to that with which the rib articulates. Lying in front of the Stellate ligaments are the pleura of the lungs and the thoracic portion of the sympathetic trunk, and on the right side, the azygos vein.

(c) **The Interarticular Ligament** is a short band of fibers extending from the head of the rib to the intervertebral disc, and is attached to capsular ligament in front and behind. It divides the joint cavity into an upper and lower part. Each part is separate from the other and has its own synovial membrane. The interarticular ligament is absent in the first, tenth, eleventh,

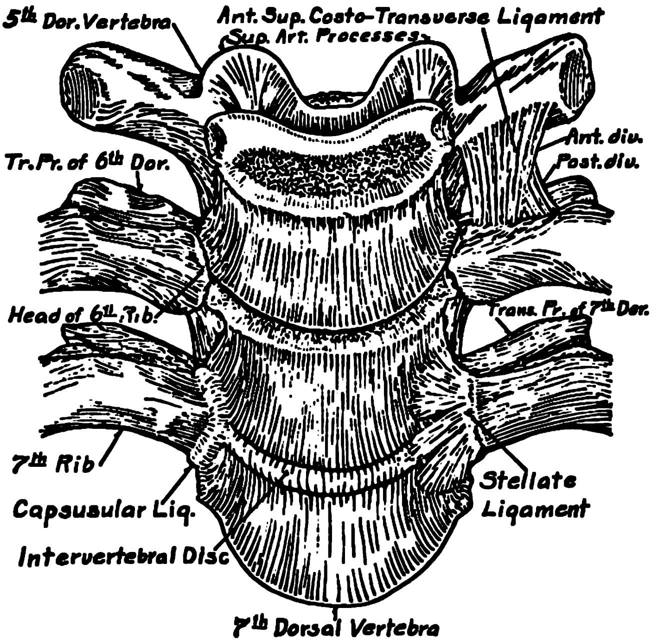


Fig. 29. Anterior view of three thoracic vertebrae with attached ribs and ligaments.

and twelfth joints where the rib articulates with only one vertebra.

2. **Costotransverse Articulations**—The joints are formed by the convex articular surfaces of the tubercle of the rib joining the concave articular surfaces of the thoracic transverse processes. The joints are usually absent in the eleventh and twelfth ribs.

The costotransverse articulations are classified as freely movable, gliding joints with slight rotation. The ligaments of the costotransverse articulations are:

(a) The Articular Capsule

(b) The Anterior Costotransverse

(c) The Posterior Costotransverse

(d) The Ligament of the Neck of the Rib

(e) The Ligament of the Tubercle of the Rib

(a) The Articular Capsule is a thin, loose, membrane attached to the edges of the articulating surfaces.

(b) The Anterior Costotransverse Ligament is a wide, flat band that passes upwards and sidewards from the upper border of the neck of the rib to the lower border of the transverse process next above. It is absent on the first rib.

(c) The Posterior Costotransverse Ligament is a thin band extending from the neck of the rib upward and medialward to the base of the transverse process and the lateral border of the inferior articular process of the vertebra above.

(d) The Ligament of the Neck of the Rib is made up of a short, strong band connecting the posterior of the neck of the rib with the anterior surface of the transverse process with which the rib articulates. In the eleventh and twelfth ribs, this ligament is rudimentary or absent.

(e) The Ligament of the Tubercle of the Rib, or the Posterior Costotransverse Ligament is a short, thick, strong ligament connecting the rough part of the tubercle to the tip of the transverse process. The joint and ligaments are missing in the eleventh and twelfth ribs.

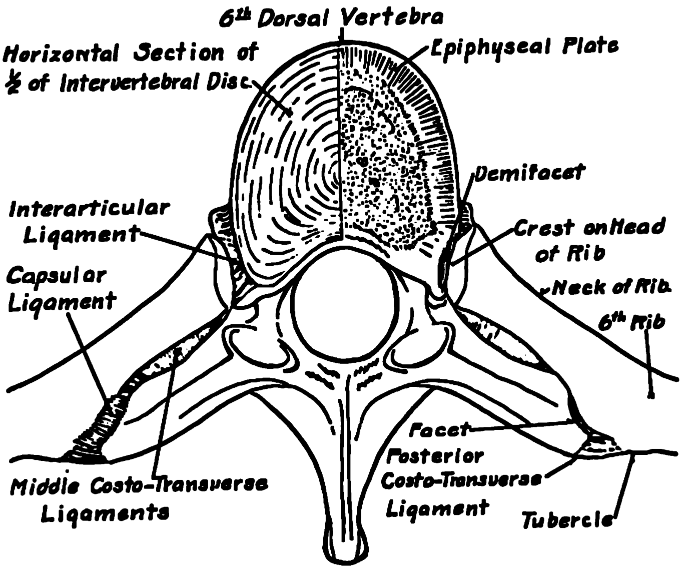


Fig. 30. Superior view of the 6th thoracic vertebra with attached ribs and ligaments.

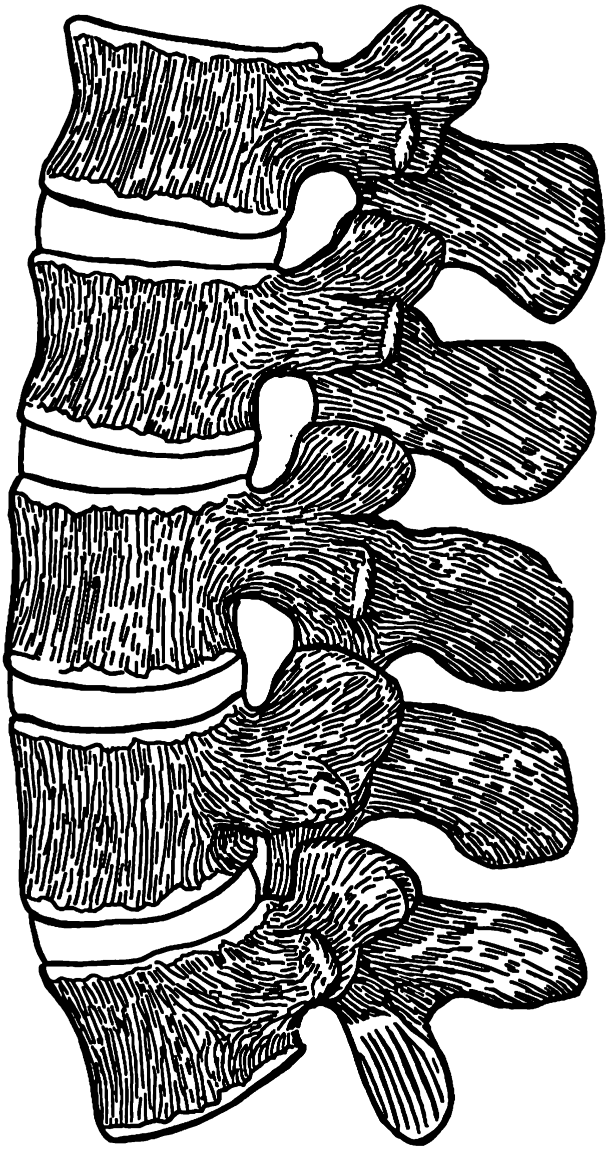


Fig. 31. Lateral view of lumbar region.

LUMBAR VERTEBRAE

The lumbar vertebrae, five in number, are distinguished chiefly by their large size for weight bearing, by the absence of costal facets, and by the absence of foramina in the transverse processes. However, the lumbars present certain characteristics common to each of the five members.

Body—The body of a lumbar vertebra is large and kidney shaped. It is wider from side to side than before backward, and it tends to be thicker at the anterior than at the posterior. The superior and inferior surfaces of the body are nearly flat, or at most, slightly concave; the anterior surface is convex from side to side and concave from above downward. The posterior surface is slightly concave in both directions.

Pedicles—arise from the upper part of the body and are projected to the posterior on a horizontal plane. They are short and very strong, and each gives rise to a shallow superior vertebral notch and a very deep inferior vertebral notch.

Laminae—are short, broad, and strong; they run in a nearly vertical plane. Each lamina is separated from the one below by a gap near the median end, and this gap is greatest between the 4th and 5th lumbars.

Spinous Process—is thick and broad and somewhat hatchet-shaped projecting backward in an almost horizontal direction. Its free end shows a broad, thick, uneven surface which is occasionally notched on the inferior.

Transverse Processes—are long, slender, and somewhat flattened on their anterior and posterior surfaces. They arise from the pedicles or the junctions of the pedicles and the laminae, slightly to the posterior. They are longest in the third lumbar vertebra, and successively shorter in the fourth, second, and fifth, while the first lumbar shows the shortest pair of transverse processes. On the posterior surface of the base of each transverse process is a small tubercle called the **Accessory Process.** The transverse processes of the upper three lumbars extend horizontally, but in the lower two they incline slightly upward.

Vertebral Foramen—is large and triangular, being wider than in the thoracic region but not so wide as in the cervical region.

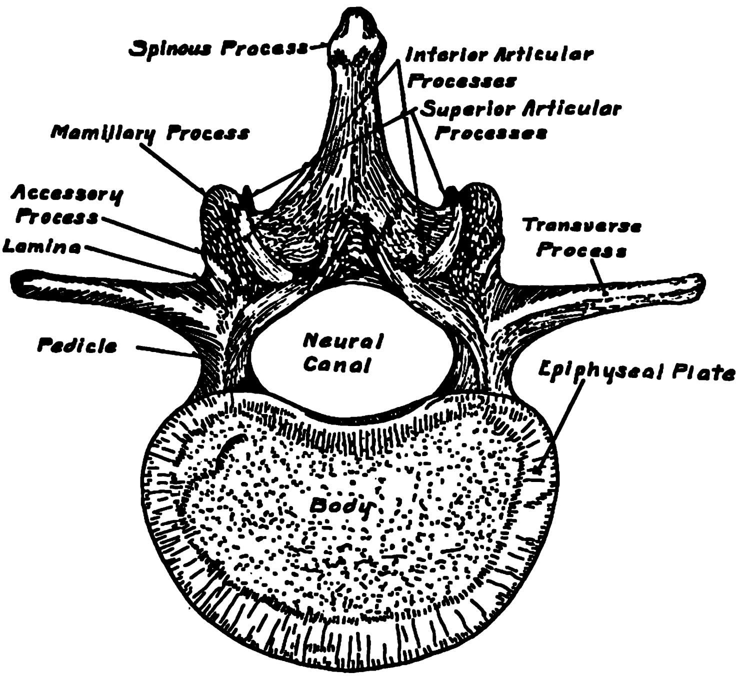


Fig. 32. The second lumbar—a typical lumbar vertebra.

Articular Processes—The superior and inferior articular processes are large, thick, and strong. The superior articular surfaces are concave and directed backward and medialward; those on the inferior processes are convex and run forward and lateralward. The superior processes of each lumbar are wider apart than are the inferior pair.

Mamillary Processes—On the posterior-superior edge of each superior articular process is a rounded tubercle called a mamillary process. The mamillary process corresponds to the superior tubercle noted in connection with the transverse processes of the lower three thoracic vertebrae, and afore-mentioned. The lumbar **Accessory Process** corresponds to the inferior tubercle of the superior, inferior, and lateral tubercles described on each lower thoracic transverse.

Special Characteristics of First Four Lumbars

First—The posterior surface of the body is often thicker than the anterior.

Second—The posterior and anterior body surfaces are of equal thickness.

Third—The transverse process of the third lumbar is longest of any, and part of it arises from the pedicle. Anterior body surface is thicker than posterior.

Fourth—The inferior articular processes are as wide apart as the superior pair; the anterior body surface is thicker than the posterior.

Fifth—The fifth lumbar vertebra is considered as a peculiar or atypical lumbar.

PECULIAR OR ATYPICAL LUMBARS

The fifth lumbar is given as the one peculiar lumbar vertebra because of several unusual features.

1. **Size**—It has the largest circumference of all vertebrae.
2. **Body**—The body is much thicker at the anterior than at the posterior, but its over-all thickness is less than the lumbars above. It articulates below with the base of the sacrum to form the **Sacro-Vertebral Angle.**

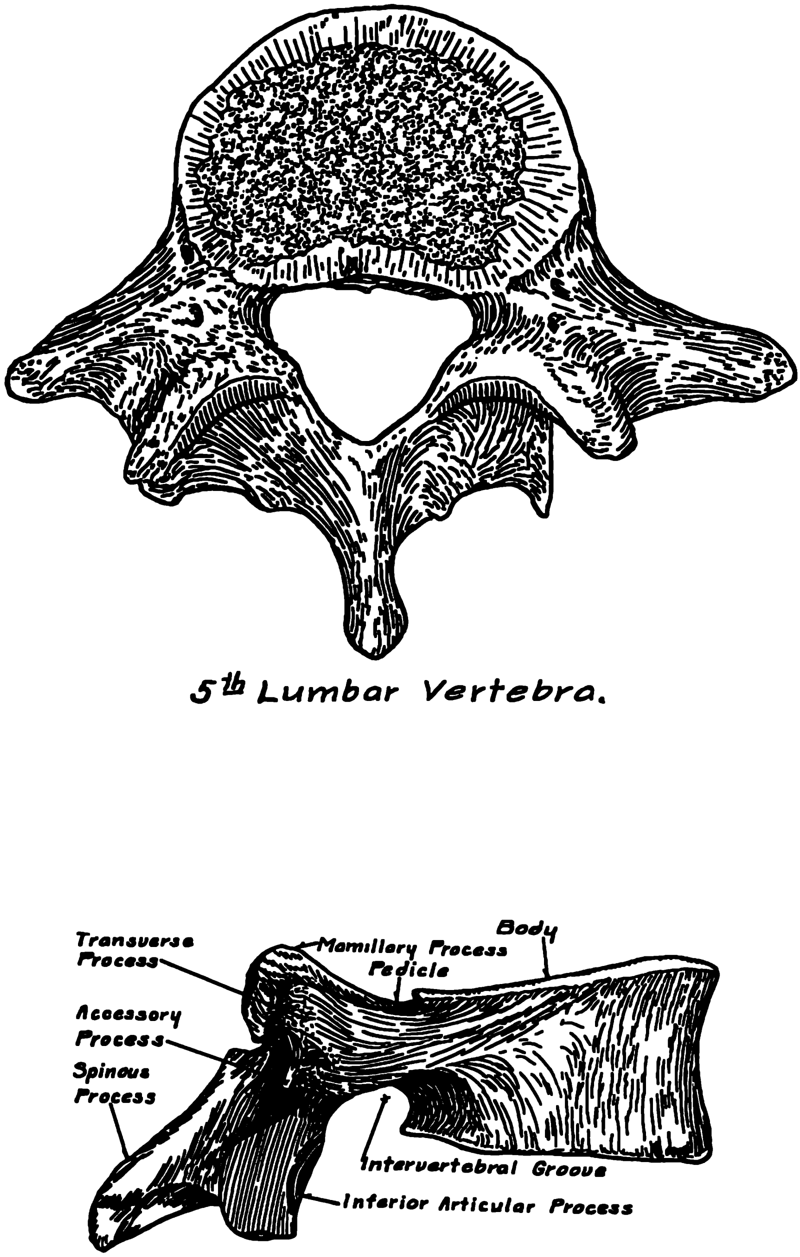


Fig. 33. Superior and lateral views of the 5th lumbar—a peculiar lumbar.

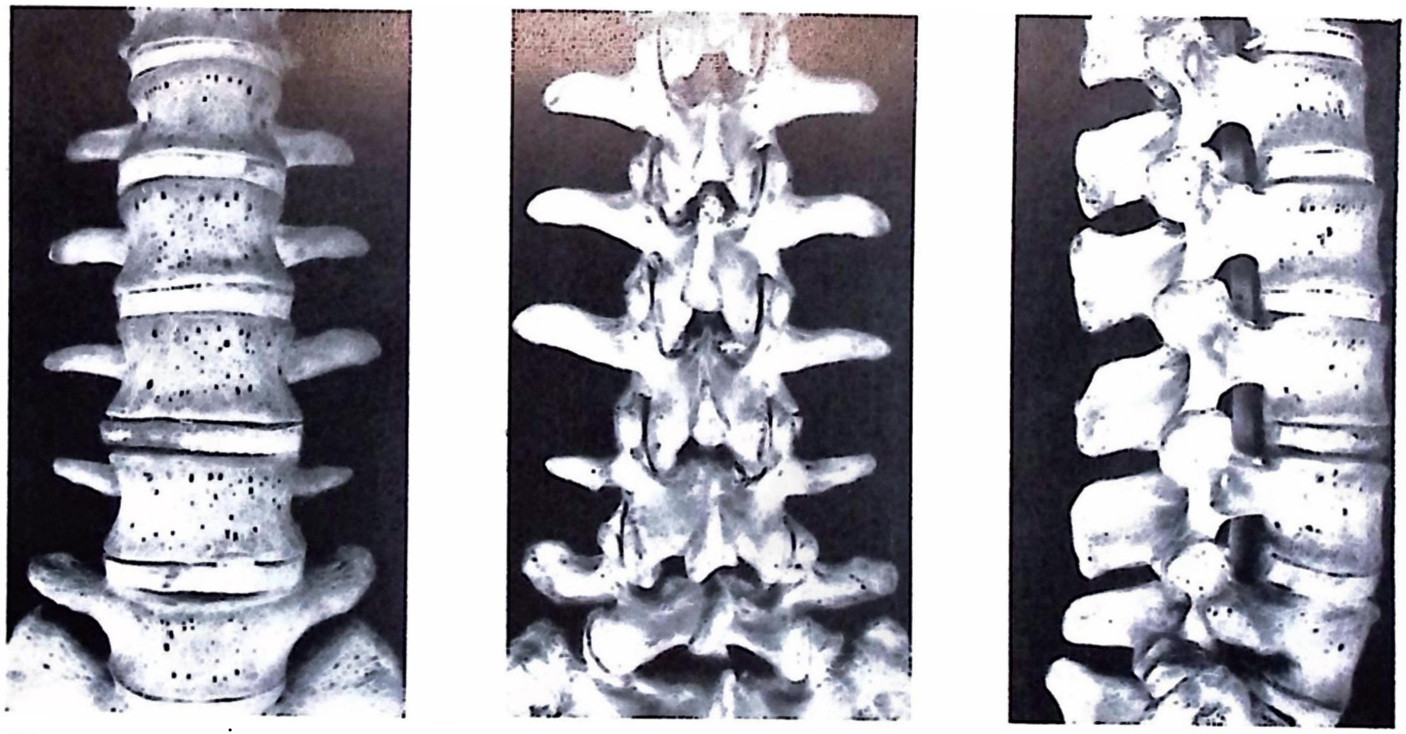


Fig. 34. Anterior, posterior and lateral views of the lumbar region. Identify the anatomical parts to be seen on each view.

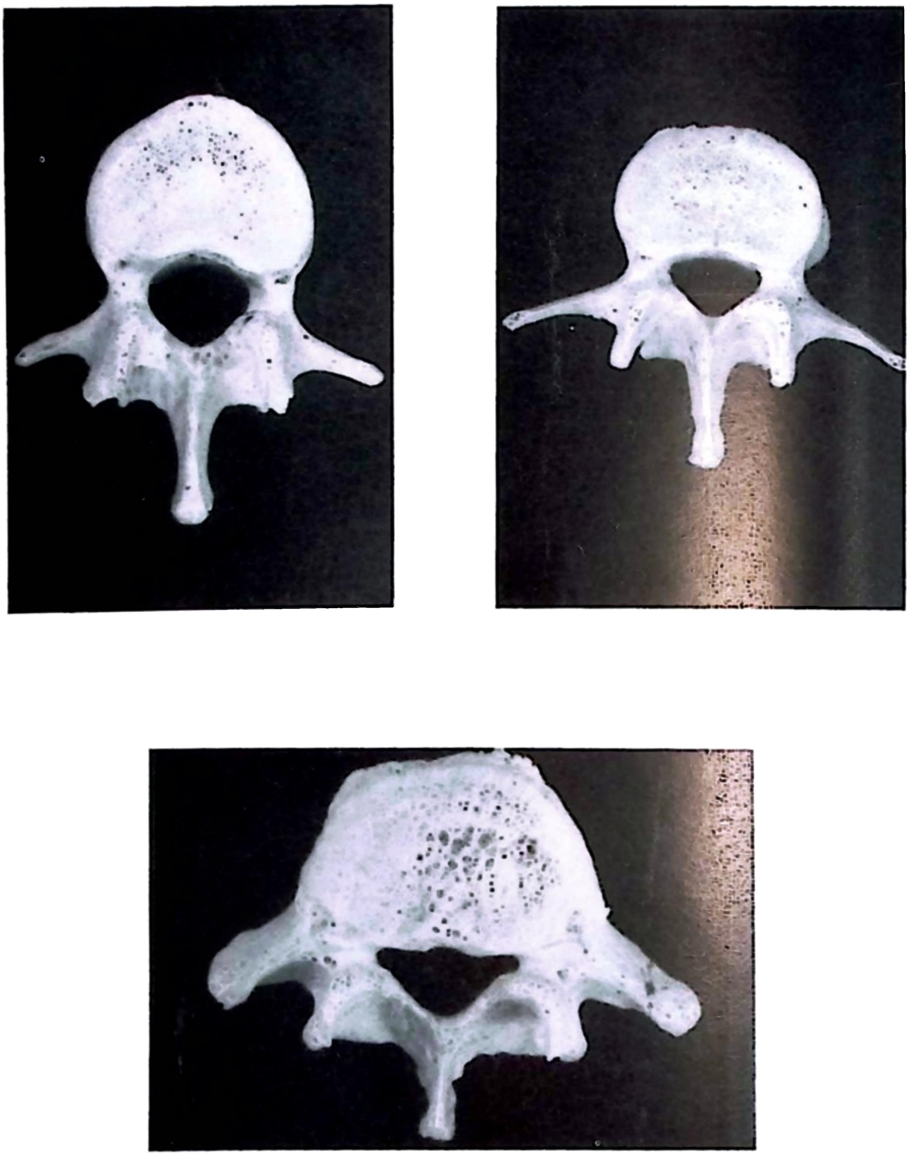


Fig. 35. The 1st, 3rd, and 5th lumbars. Identify the important descriptive parts of each.

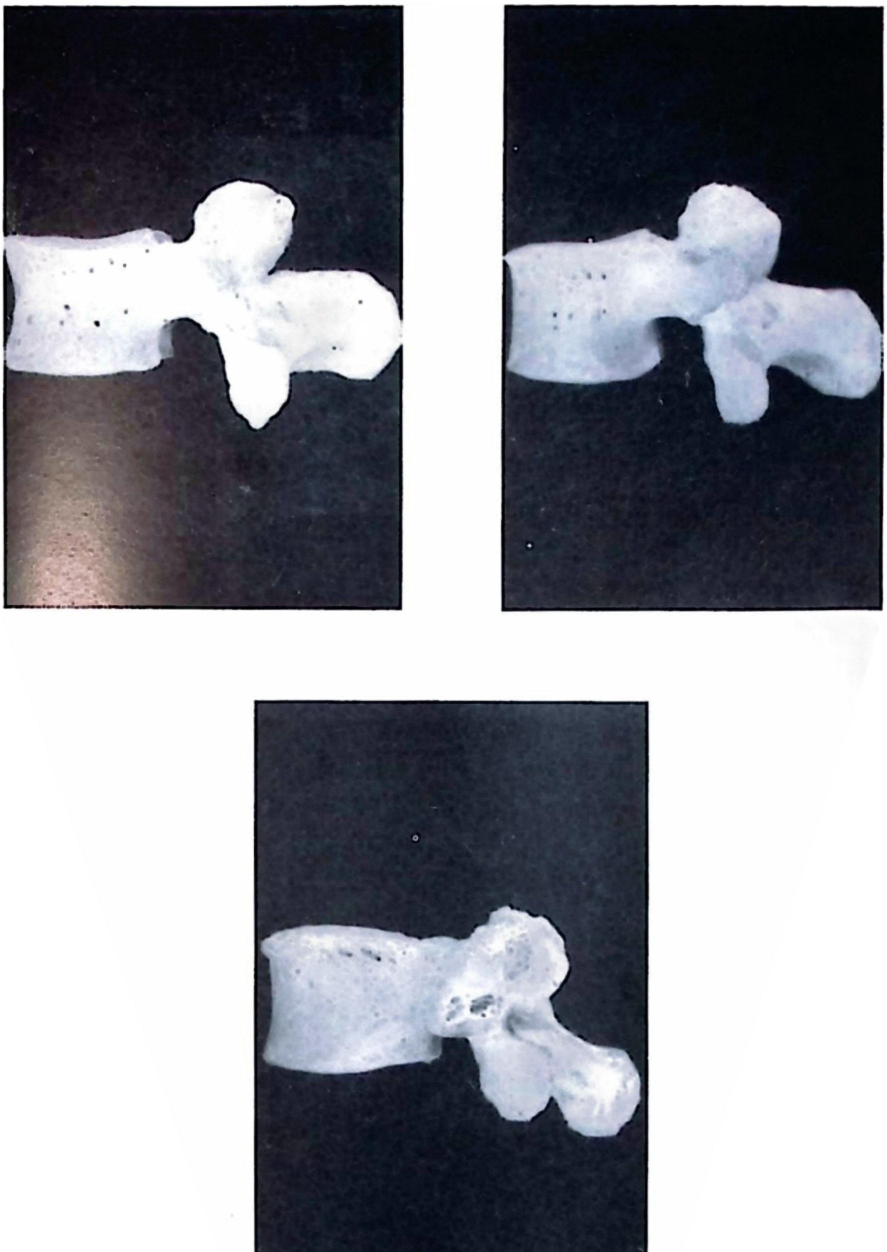


Fig. 36. Lateral views of the 1st, 3rd, and 5th lumbars. Identify features of each.

Superior Surface of Base of Sacrum.

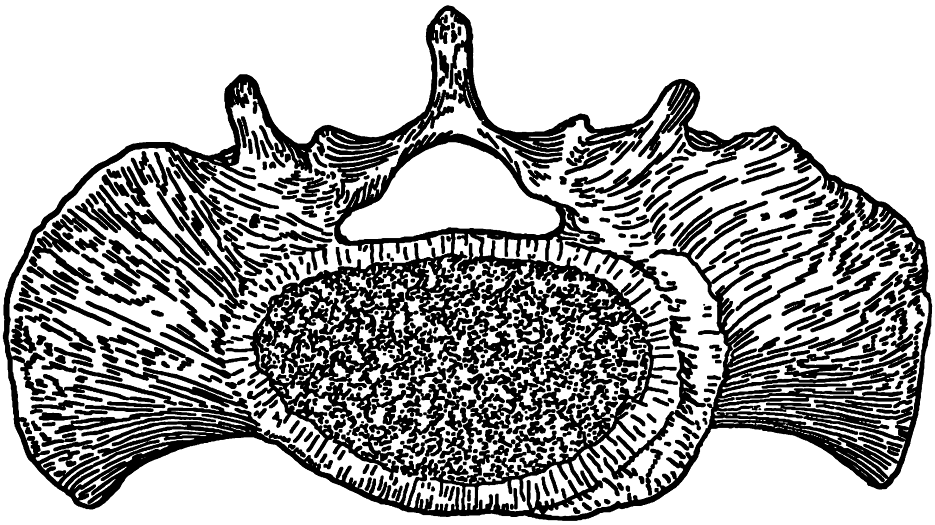


Fig. 37. Superior surface of base of sacrum.

3. **The Transverse Processes** are short, strong, thick, and pyramidal in cross section, and arise from the pedicle as well as the body.

4. **Spinous Process** is shorter than those of the other lumbars, and is rounded on its free extremity.

5. **Superior Articular Processes** are directed more backward and less medialward than the other lumbars.

6. **Inferior Articular Processes** are directed more forward and less lateralward than the other lumbars, and they are farther apart than the superior articular processes.

THE SACRUM

In early life, the sacrum consists of five separate segments which are united in the adult to form the single OS SACRUM.

The sacrum is a large, triangular bone located at the lower part of the spinal column and lying between the hip bones to which it is firmly connected. Its upper part articulates with the fifth lumbar vertebra and its lower part with the coccyx. Of the five segments composing the sacrum, the highest, or first, is the largest, and each succeeding segment decreases materially in size. In a normal standing position, the lengthwise plane of the sacrum is obliquely backward and downward.

The following descriptive parts are considered in a study of this important bone which helps form the base of the spinal column.

1. **Base**—is directed upward and forward, and is broad and expanded, having a marked similarity to the superior surface of the fifth lumbar vertebra. In the center of the base is a large, oval articular surface which articulates with the body of the fifth lumbar above and is joined to it by an intervertebral disc. The anterior margin of the sacrum base projects forward and is known as the **Sacral Promontory**—an important landmark in Anatomy and Obstetrics. Behind the body a large, sloping triangular opening, the **Vertebral Foramen**, leads into the **Sacral Canal.**

On either side of the canal are two **superior articular processes** which are oval and concave on their articular surfaces, and

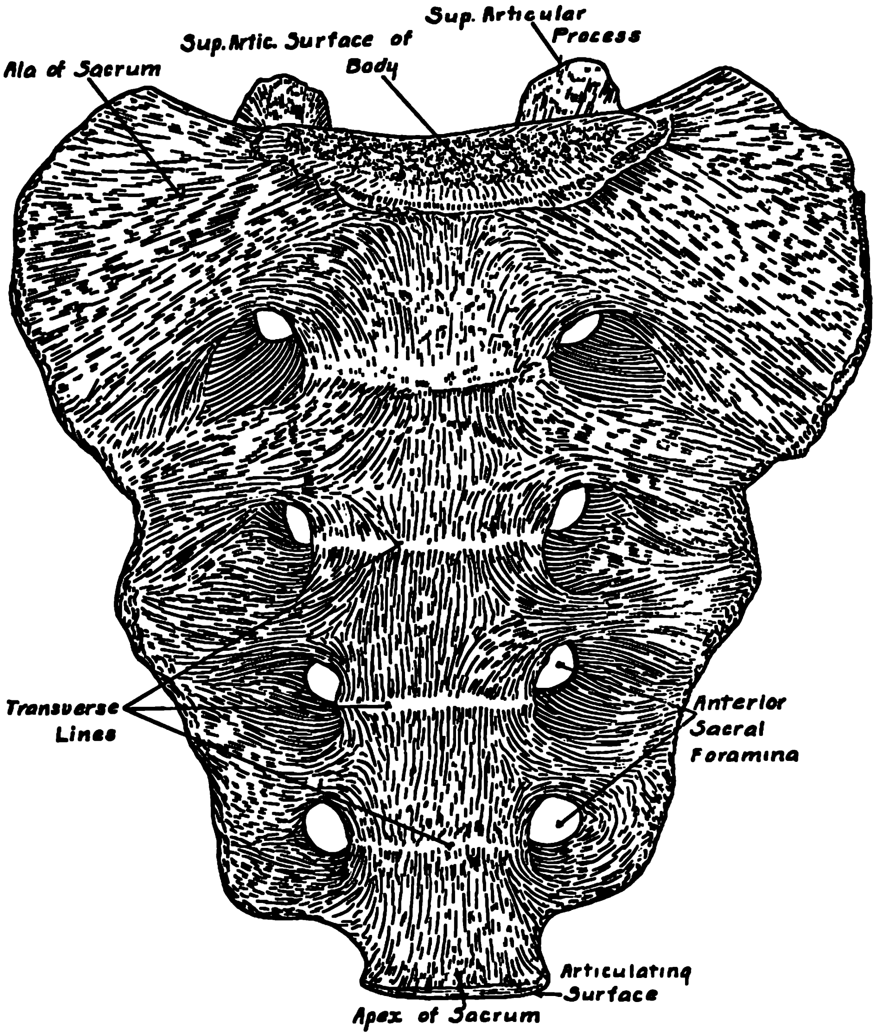


Fig. 38. Pelvic surface of the sacrum.

run backward and medialward like the superior articular processes of a lumbar vertebra. They arise from the body of the first sacral segment and the ala by means of short thick pedicles; on the upper surface of each pedicle is a deep notch which forms the lower part of the intervertebral foramen between the fifth lumbar and the first sacral segment.

The Alae of the sacrum form the bases of the lateral mass and extend laterally from the sides of the body. The ala is concave from side to side; convex from before backward. It slopes downward and forward and is often slightly grooved for the passage of the lumbo-sacral nerve trunk. Its broad surface gives attachment for the iliacus muscle.

The lateral margin of each sacral ala ends posteriorly in a tubercle which represents the transverse process of the first sacral segment. The anterior part of the ala corresponds to the costal process.

2. Apex—is the lower surface of the body of the fifth sacral segment. It is oval in shape, and articulates with the coccyx by means of an intervertebral disc, although in middle age, the sacrum, apex, and coccyx are usually united by bone.

3. Pelvic Surface—is smooth, concave in all directions, and is directed downward and forward. It is crossed in the middle part by four transverse ridges or lines which represent the ossified intervertebral discs between the original five sacral vertebrae. These lines end at the Anterior Sacral Foramina; four in number on each side which give exit to the anterior divisions of the sacral nerves and permit entrance of the lateral sacral arteries. The anterior sacral foramina diminish in size from above downward and are nearly round in form. Lateral to these foramina are the lateral parts of the sacrum, a right and a left, each of which supports four broad shallow grooves extending laterally from the openings of the anterior foramina. These grooves convey the anterior divisions of the sacral nerves leaving the foramina; between successive grooves are bony ridges which give attachment to the Piriformis muscle.

4. Dorsal Surface or posterior surface—is convex and irregular, giving origin to the powerful sacro-spinalis muscle. In the median line is the Middle Sacral Crest which supports three or four Sacral Tubercles representing the rudimentary spinous processes of the upper three or four sacral vertebrae. On either

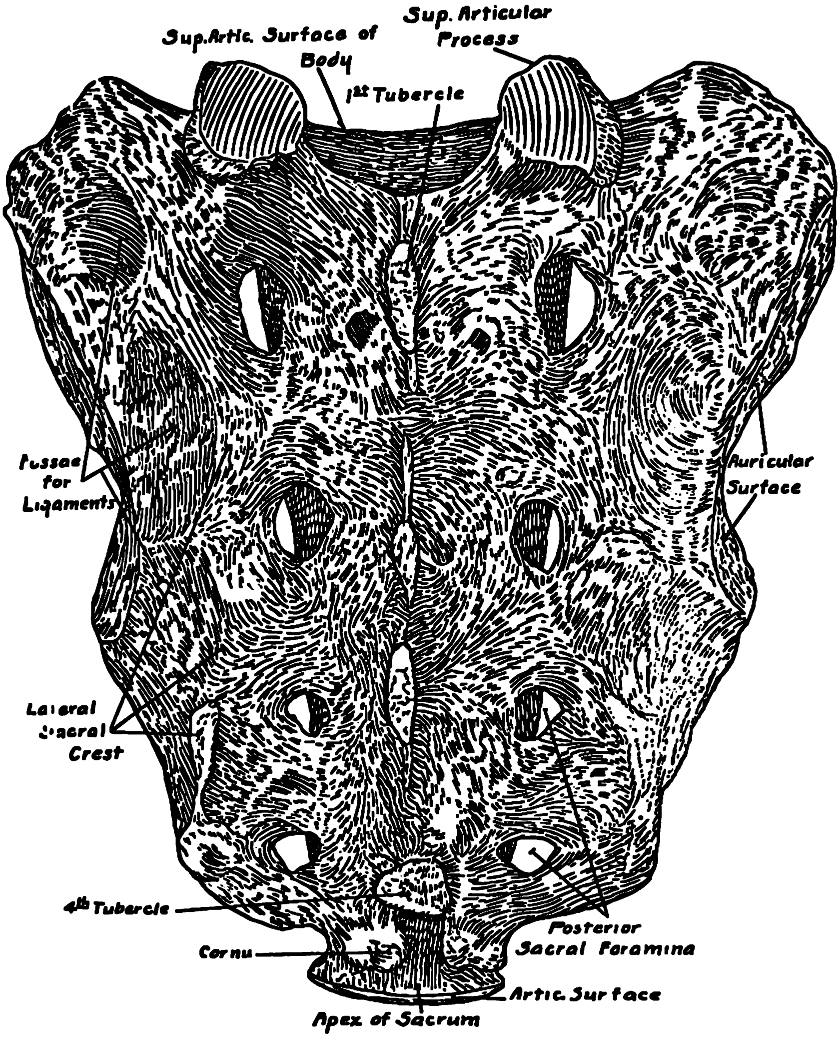


Fig. 39. Dorsal or posterior surface of the sacrum.

side of the crest is a shallow **Sacral Groove** whose floor is formed by the joined laminae of the first four sacral vertebrae. The failure of the two laminae of the fifth sacral segment to meet posteriorly leaves an oblique opening called the **Sacral Hiatus** which is the lower end of the sacral canal. On the lateral edge of the sacral groove is a series of small tubercles, the **Sacral Articular Tubercles or Crests** representing the rudimentary articular processes. However, the superior articular processes of the first sacral segment are well developed, being large and oval, and they articulate with the inferior articular processes of the fifth lumbar. The articular tubercles or crests of the fifth sacral segment are small, narrow projections of bone called the **Sacral Cornua** and they run downward to articulate with the coccygeal cornua as well as forming the lateral boundaries of the sacral hiatus. Lateral to the articular tubercle is a vertical row of four **Posterior Sacral Foramina** on each side. These also decrease in size from above downward. They lie directly behind the anterior sacral foramina and each is slightly smaller than its corresponding anterior foramen. The posterior sacral foramina transmit the posterior divisions of the sacral nerves.

On the lateral side of each row of posterior foramina is a series of blunt tubercles which collectively form the **Lateral Crests** of the sacrum. The tubercles are rudimentary transverse processes of the sacral vertebrae.

5. **Lateral Surfaces**—of which there are two, right and left. The superior part is thick and broad, but narrows toward the inferior. The upper portion presents on its anterior and lateral surface a large ear-shaped **Auricular Surface** for articulation with the ilium. On the posterior surface of the upper portion is a rough irregular projection for the attachment of the interosseous and posterior sacroiliac ligaments, and this elevation is known as the **Sacral Tuberosity.**

The inferior part of the lateral surface corresponds to the fourth and fifth sacral segments and it is relatively thin with an irregular surface for the attachment of the greater and lesser sacro-sciatic ligaments. The inferior portion ends in a projection known as the **Lateral Inferior Angle.**

Directly below the angle is a notch converted into a foramen by the transverse process of the first coccygeal vertebra and the anterior division of the fifth sacral nerve emits through this foramen.

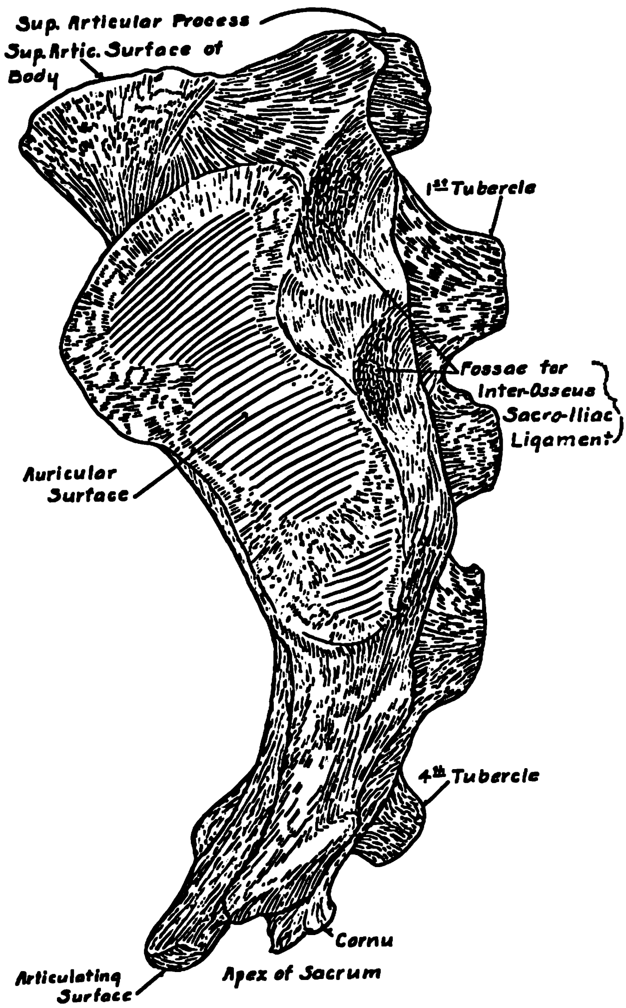


Fig. 40. Lateral surface of the sacrum.

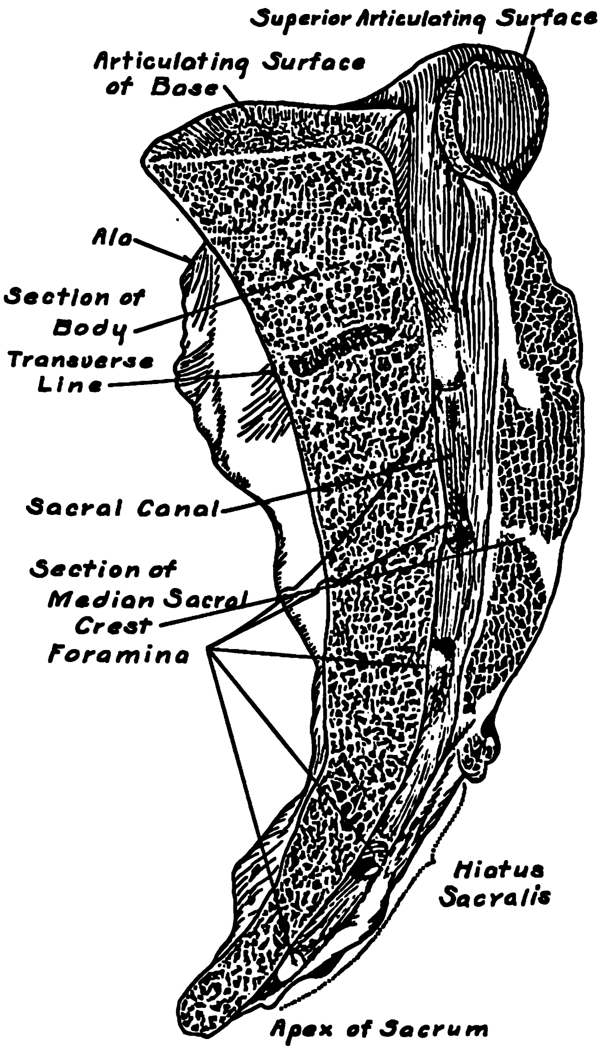


Fig. 41. Longitudinal section of sacrum.

Fig. 42. The coccyx—posterior view.

6. **Sacral Canal or Vertebral Canal**—is wide and triangular above, small and flattened below. It runs the length of the sacrum and on each side-wall there are four **Intervertebral Foramina** which communicate with both the anterior and posterior sacral foramina. It usually terminates at the sacral hiatus between the sacral cornua, and its posterior wall here is formed by the superficial posterior sacro-coccygeal ligament.

The sacral canal contains the roots of the sacral and coccygeal nerves, the filum terminale, and the dura mater and arachnoid meninges. The sub-arachnoid space runs through it as far as the second sacral segment, and the spinal plexus of veins and the lateral sacral arteries are also enclosed within the sacral canal. The sacral hiatus transmits the filum terminale, the roots of the fifth sacral nerve, and the coccygeal nerves.

The Female Sacrum—is relatively wider than the male sacrum, and shows a less distinct curve, being flat above and abruptly curved below. The plane of the female sacrum is more posterior which accounts for the increased anterio-posterio diameter of the female pelvis.

THE COCCYX

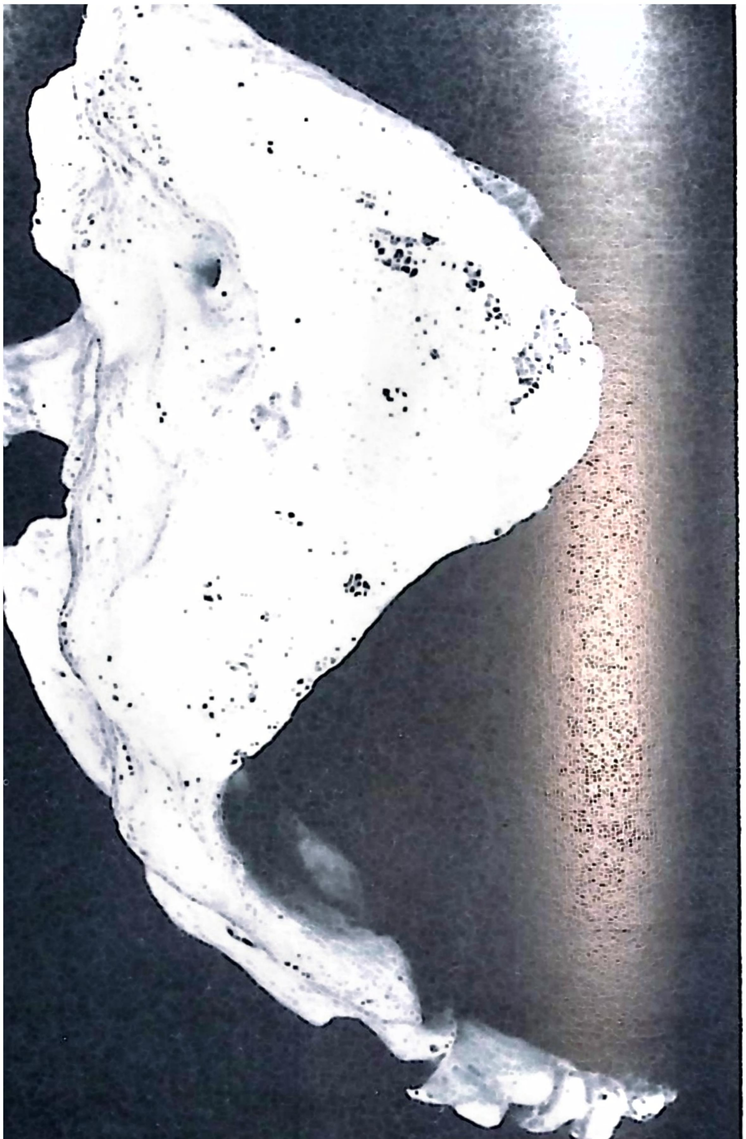
The coccyx is triangular in shape with the apex downward. It is formed of four rudimentary vertebral bodies which tend to fuse; the number, however, may be increased to five segments or decreased to three. None of the coccygeal segments show pedicles, laminae, or spinous processes.

The descriptive parts of the coccyx are: base, apex, dorsal and pelvic surfaces, and lateral borders.

Base—is formed by an oval, concave facet on the body of the first segment which articulates with the body of the fifth sacral segment.

Apex—is rounded, and is merely a small tubercle representing the fourth segment. It gives attachment to the tendon of the external sphincter ani muscle.

Dorsal Surface—The posterior surface of the coccyx is convex, and presents on either side a row of tubercles from above downward representative of the rudimentary articular processes. Of these tubercles, the first pair, arising from the posterior of the



Sacrum and coccyx. Identify this view and study the anatomical parts.

Fig. 44. Sacrum and coccyx. Identify this view and study the anatomical parts.

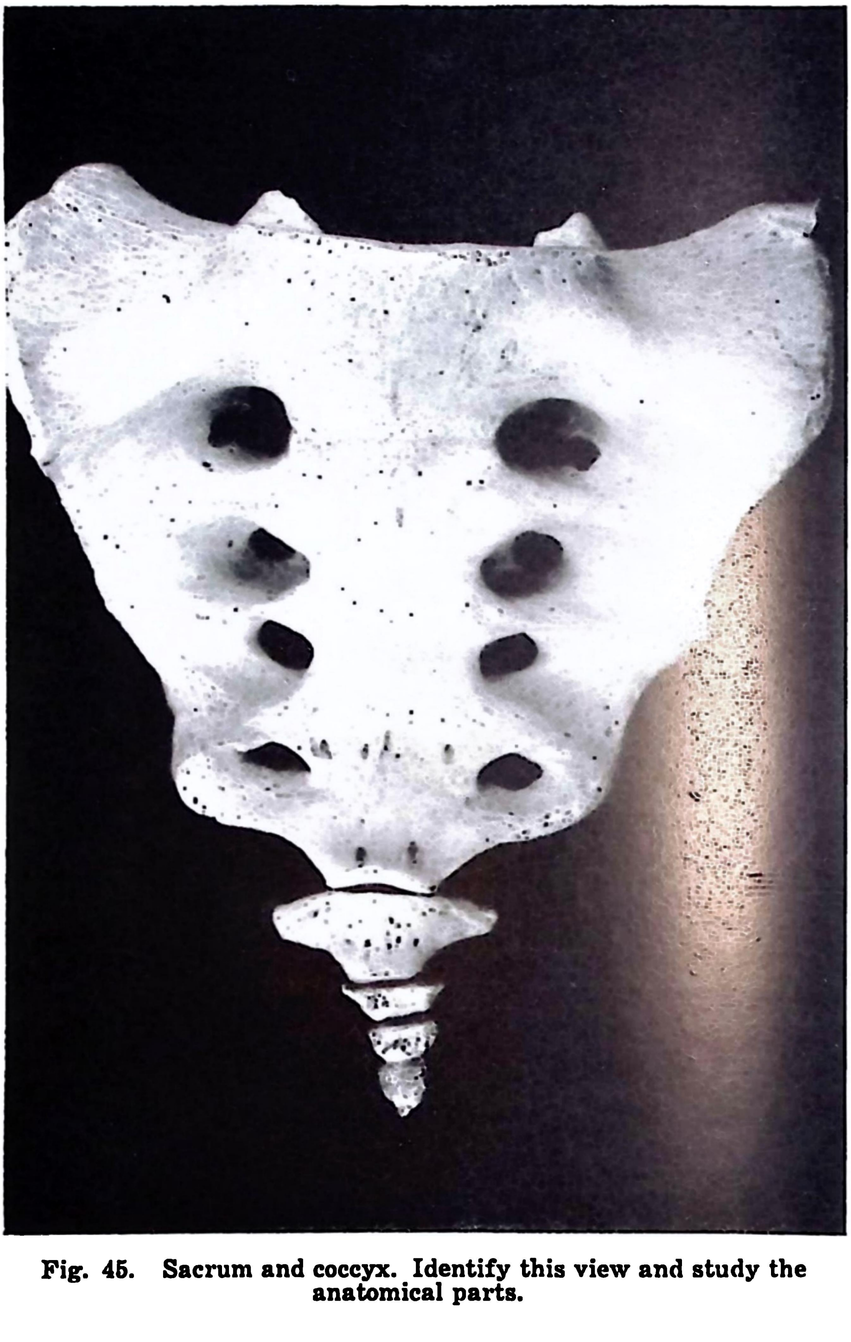


Fig. 45. Sacrum and coccyx. Identify this view and study the anatomical parts.

body of the first segment, are the largest, and are called the **Coccygeal Cornua**; they project upward to articulate with the cornua of the sacrum, and on either side form the inferior half of the foramen transmitting the fifth sacral nerve. This foramen is the lowest intervertebral foramen of the spinal column.

The dorsal surface of the coccyx gives attachment to the filum terminale, and to some fibers of the gluteus maximus muscle, as well as to the posterior sacro-coccygeal ligament.

Pelvic Surface—or anterior surface, is slightly concave, and shows three transverse grooves which indicate the fusion of the four segments. This surface gives attachment to the anterior sacro-coccygeal ligament, and to the levator ani muscle.

Lateral Borders—are thin, and exhibit a series of small projections suggestive of rudimentary transverse processes from which arise fibers of the coccygeus and gluteus maximus muscles, and the greater and lesser sacro-sciatic ligaments. In some cases, the pair of small lateral projections on the body of the first coccygeal segment pass upward to join the lower part of the lateral edge of the fifth sacral segment to form a foramen for the transmission of the anterior division of the fifth sacral nerve. In other cases, the sacral and coccygeal cornua of each side are united by the intercornual ligament which completes this intervertebral foramen for the transmission of both anterior and posterior divisions of the sacral nerve.

The First Coccygeal Segment is the largest and is much broader than the others. It has a body, rudimentary transverse processes, and the beginnings of a vertebral arch.

The Second Segment is much smaller than the first, but still exhibits a body, traces of transverse processes, and a vertebral arch in the form of tubercles at the sides on the posterior surface of the body.

The Third and Fourth Segments are merely small nodules.

In early adulthood, the first segment is usually separated from the three lower segments which have fused; but by middle age, the four segments have all fused and frequently the coccyx is fused to the apex of the sacrum.

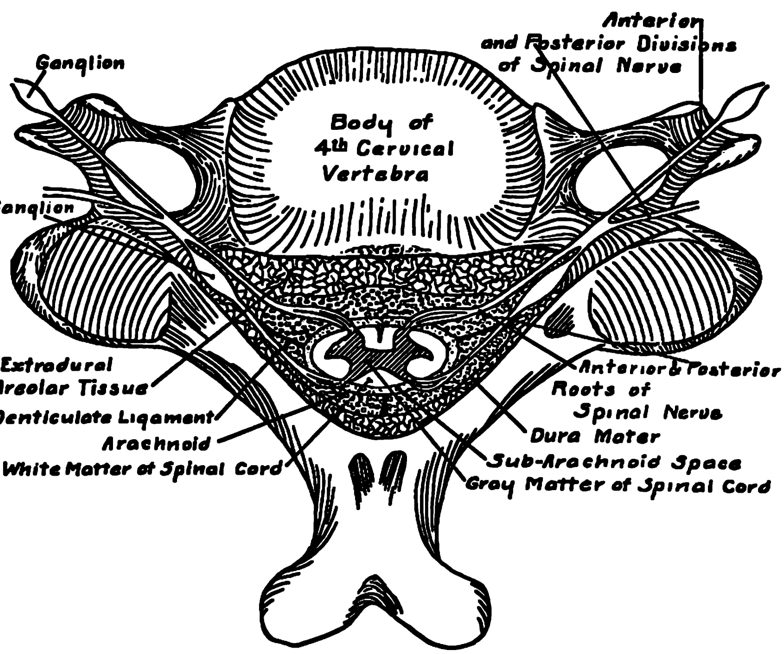


Fig. 46. Transverse section of spinal cord and neural canal in mid-cervical region.

Chapter 3

SPINAL CORD—MEDULLA SPINALIS

A study of the gross anatomy of the spinal cord assumes a rightful place in the study of Orthopedy because of its relationship to the spinal column. This is especially true of the Chiropractic approach to the anatomical features of both cord and column which are considered as coordinated integrations embracing the greatest scope of technical Chiropractic application—anatomically, clinically and functionally.

Since a detailed study of the cord belongs to Neurology and Neurophysiology only its gross anatomy will be considered here.

POSITION AND DIMENSIONS

The spinal cord is a pliable and almost cylindrical cord of nervous tissue lying in the upper two-thirds of the vertebral canal. Anteriorly it is slightly flattened to correspond to the shape of the vertebral canal. It is continuous above with the medulla oblongata which it joins at the foramen magnum, or a point on the cervical median line corresponding to a point midway between the external occipital protuberance and the spinous process of axis. In the adult it ends at the lower border of the first, or upper border of the second lumbar vertebra, but in the infant it may reach the level of the third or even the fourth lumbar spinous processes.

Its average length in the male is about 18 inches, in the female about 17 inches; while its average diameter is about one-half inch exclusive of the enlarged area. Its weight without its meninges amounts to about 30 grams or about 2 per cent of the total weight of the entire central nervous system.

EXTERNAL DESCRIPTIVE PARTS OF THE MEDULLA SPINALIS

The right and left halves of the cord are incompletely separated from each other by a fissure, a sulcus, and a septum.

The **Anterior Median Fissure** is relatively narrow and deep with its depth corresponding to about one-third of the thickness of the cord.

The **Posterior Median Sulcus** is a shallow groove on the posterior median surface of the cord.

The **Posterior Median Septum** is a thin strip of neuroglia which arises from the floor of the sulcus and penetrates forward about half the thickness of the cord.

The tapering lowest part of the spinal cord is called the **Conus Medullaris.**

The **Central Canal** runs throughout the entire length of the medulla spinalis and is continued down into the filum terminale for a distance of one to three inches.

ENLARGEMENTS

The spinal cord maintains a uniform thickness in the greater part of its length, but at the two areas where the large nerves supplying the limbs arise it presents two enlargements—an upper or cervical enlargement, and a lower or lumbar enlargement.

The **cervical enlargement** is the greater of the two, and it extends from the level of the axis' inferior surface to the second dorsal with its maximum thickness opposite the sixth cervical.

The **lumbar enlargement** commences at the level of the ninth or tenth thoracic vertebra and reaches its greatest thickness opposite the twelfth thoracic vertebra and then tapers rapidly into the conus medullaris.

DIVISIONS

Thirty-one pairs of spinal nerves arise from the medulla spinalis and the grouping of these nerves according to location subdivides the cord into four parts or regions:

(1) the cervical portion, with eight pairs of cervical nerves; (2) the thoracic portion, with twelve pairs of thoracic nerves; (3) the lumbar portion, with five pairs of lumbar nerves; and (4) the sacral portion, with five pairs of sacral and one pair of coccygeal nerves. Some anatomists place the pair of coccygeal nerves in a fifth or coccygeal portion of the spinal cord.

Note that there are eight cervical nerves although there are but seven cervical vertebrae.

The upper seven cervical nerves emit through intervertebral foramina above the corresponding vertebrae and the eighth cervical leaves below the seventh cervical vertebra. Below that, each nerve leaves by way of a foramen *below* the corresponding vertebra.

Each spinal nerve is attached by two *roots*—an anterior root made up of motor fibers, and a posterior root, of sensory fibers. The spinal cord is divided into segments or neuromeres by the attachment of the spinal nerve roots, and each segment corresponds to the length of that particular section of the cord from which the roots arise. For example, the first cervical segment includes a disc-like transverse section of the spinal cord equivalent to the length or height of the first cervical pair of spinal nerves, and the second thoracic segment includes this part of the cord and its second thoracic nerve roots. This method of dividing the cord is simply a means of artificially creating individual areas because there is no anatomic evidence of segmentation.

Since spinal nerve roots vary in thickness, so will the spinal segments. In the cervical region the segments average about one inch in length, while in the lumbo-sacral region they decrease gradually from one-half inch at the first lumbar nerve attachment level to a thickness of one-fourth inch at the attachment of the fifth sacral nerve roots.

As the spinal cord in the adult is considerably shorter than the vertebral column the lower pairs of spinal nerves must descend almost vertically within the vertebral canal until they reach the intervertebral foramen through which they will be transmitted. In the upper cervical region the spinal nerves emit almost horizontally, but they become directed more obliquely downwards in the lower cervical region and this downward angle

is so great in the thoracic region that most thoracic spinal nerve roots run downwards within the vertebral canal for the length of about one vertebra before emitting. The lumbar and sacral nerve roots arise from spinal cord segments very much higher in the vertebral canal than the foramina through which they leave; for instance, the third and fourth sacral nerve roots arise from the spinal cord at about the level of the first lumbar vertebra but they descend all the way down through the lumbar and sacral vertebral canals to the sacral foramina. It is this large group of lower spinal nerve roots running parallel to one another in the vertebral canal of the lumbar region which is given the name Cauda Equina because of its similarity in appearance to a horse's tail.

Chiropractors should particularly consider this difference in levels of spinal root attachment and spinal nerve transmission through intervertebral foramina because of its clinical importance in certain cases. For example, an injury to the fifth thoracic vertebra will not directly involve the fifth thoracic segment of the spinal cord because it is located at about the level of the fourth thoracic vertebra; instead, such an injury will affect the sixth thoracic spinal cord segment.

MENINGES OF THE SPINAL CORD

The spinal cord is surrounded by three tubular fibrous membranes or meninges which, named from without inwards, are dura mater, arachnoid mater and pia mater. These membranes are continuous with the corresponding meninges covering the brain.

1. **Dura Mater** is the outer of the spinal meninges and is a direction continuation of the visceral layer of the cranial dura. The spinal dura has but a single layer, whereas the cranial dura mater is composed of two layers, parietal and visceral. The parietal layer as such does not leave the cranial cavity, but terminates at the foramen magnum and is replaced by the periosteum lining the vertebral canal.

The spinal dura mater is a tough fibrous membrane, dense and strong, bluish-white in color, which extends from the foramen magnum of the skull to about the level of the second sacral segment. Below this point it narrows greatly to form a fibrous cord which blends with the posterior longitudinal ligament of the

coccyx and fuses with the periosteum of the coccyx. This filament is called the **Coccygeal Filum or Ligament** and represents the lower anchoring point of the dura mater.

The dural tube is also anchored to the vertebral canal in the upper spinal regions by being firmly attached to the margin of the foramen magnum, the posterior surfaces of the bodies of axis and third cervical and in other spinal regions it is attached at irregular intervals to the posterior longitudinal spinal ligament, particularly in the lower cervical and upper lumbar regions.

The spinal dura mater helps form the outside coverings of each pair of spinal nerve roots as they enter their respective intervertebral foramina and as such it becomes continuous with the periosteum lining each foramen.

Below the level of termination of the spinal cord the spinal nerve roots of the cauda equina lie free in the tubular cavity of the dura mater but as they pass outwards into their corresponding intervertebral foramina of emission they are invested with a layer of dura in the same manner as found in higher regions of the vertebral canal.

The inner surface of the spinal dura is smooth and covered with a layer of mesothelial cells. Along its lateral walls the inner surface is firmly attached at irregular intervals to the pia mater by the tooth-like processes of the **ligamenta denticulata.**

2. **Arachnoid.** The arachnoid coat of the spinal cord is a thin, delicate, transparent membrane which loosely invests the cord. It, like the dura mater, is made up mostly of white fibrous tissue with some elastic tissue; the two being intimately blended together. Above, the arachnoid is continuous with the cranial arachnoid, and below it forms a covering of the nerve roots making up the cauda equina. Also, the arachnoid covers the spinal nerve roots and extends into the intervertebral foramina in much the same manner as does the dura mater.

The arachnoid is connected with the pia mater on each side by the teeth of the **ligamentum denticulatum,** and posteriorly, by the weak, incomplete, median **subarachnoid septum.**

3. **Pia Mater.** The pia mater is sometimes referred to as the "blood vessel layer of the meninges" because it is the membrane which the blood vessels ramify before they enter the spinal cord. It is a thin delicate membrane closely adherent to the spinal cord,

ending at the conus medullaris, but some of its fibers are prolonged as a thin, slender, shiny, fibrous thread, called the **Filum Terminale** which pierces the lower ends of the arachnoid and dural tubes and finally fuses with the periosteum of the posterior surface of the coccyx.

The spinal pia mater is made up of areolar tissue consisting of two layers, an outer and an inner. The outer layer is composed of fibrous connective tissue arranged in a longitudinal direction and the inner layer shows a circular arrangement to its fibers.

Although the two layers lie closely together many small spaces can be seen between them and these spaces communicate with the subarachnoid space.

Not only does the pia mater intimately invest the spinal cord but it forms sheaths for the spinal nerve roots as well. These sheaths are closely connected with the nerve roots and blend with the spinal nerve arachnoid and dural coverings in the intervertebral foramina.

The pia mater dips into the anterior median fissure of the spinal cord as a double fold which lines the fissure, and at the surface, between the lips of the fissure it becomes thickened into a band running lengthwise down the ventral midline of the cord. This thickened band is the **linea splendens** and it supports the anterior spinal artery.

From each lateral surface of the spinal cord the pia mater gives off a double fold of membrane, the **dentate ligament** or **ligamentum denticulatum**, that passes outwards towards the dura. Its medial border is continuous with the pia mater investing the cord but its lateral border presents a series of triangular pointed processes which attach directly to the inner surface of the dura after having either pierced the arachnoid or crowded it against the dura.

There are 21 of these tooth-like projections on each of the two dentate ligaments and each dentation lies between the anterior nerve roots of a spinal nerve.

The highest of these projections is attached to the dura mater opposite the margin of the foramen magnum and the lowest arises at about the level of the first lumbar vertebra near the end of the cord.

The ligamentum denticulatum plays the most important part in the suspension of the spinal cord in the subarachnoid space. It tends to prevent undue twisting or torsion of the cord besides acting as a sling to support the cord. It is aided in these important functions by the attachment of the meninges to the spinal nerve roots and the walls of the intervertebral foramina, plus the subarachnoid septum, or posticum of Schwalbe, arising from the pia mater along the posterior median surface of the cord.

MEMBRANES AND SPACES

1. **Extradural or Epidural Space** is the interval that separates the dura mater from contact with the bony vertebral canal. It is filled with a meshwork of areolar connective tissue enclosing much semiliquid white fat in which are embedded many blood vessels on their way to supply the walls of the vertebral canal, the meninges, and the spinal cord.

2. **Subdural Space.** Between the dura mater and the arachnoid, the subdural space may be compared to an unusually long, narrow serous cavity. It contains only a thin film of lymph-like fluid which serves to keep the meningeal surfaces moist.

3. **Subarachnoid Space** is located between the pia mater and the arachnoid. It is a wide space containing a large amount of cerebro-spinal fluid and above it communicates with the cranial subarachnoid cavity and below it ends in the arachnoid sac at the lower border of the second sacral vertebra.

The spinal arachnoid space is wider throughout its length than the subarachnoid space surrounding the brain, and its widest part is at the lower levels where the arachnoid covers the nerve roots of the cauda equina.

Actually there are many small cavities communicating with the space proper; and these spaces are formed in the meshes of the spongy web-like reticulum created by multitudes of small fibers or trabeculae arising from the arachnoid and attaching to the pia mater. All of these cavities are likewise filled with cerebro-spinal fluid.

The subarachnoid space dimensions vary with the different levels of the spinal column. In the cervical region the space in

front of the spinal cord is about one-quarter inch while behind the cord it averages one-sixth of an inch.

In the dorsal region the anterior part of the space is approximately one-sixth of an inch and the posterior part slightly more than a quarter of an inch. The lumbar portion shows a width of a third of an inch anteriorly and a sixth of an inch posteriorly.

Below this point the cavity of the subarachnoid space measures about one inch from anterior to posterior.

These dimensions are those of the body in the erect position but they alter with the change of position of the spinal cord during motion and the assumption of different body positions. The cord tends to come closer to the posterior margin of the vertebral canal when a person is supine, and it shifts slightly with right or left lateral spinal flexion.

CEREBRO-SPINAL FLUID

Both cranial and spinal subarachnoid spaces are filled with a clear liquid called subarachnoid fluid or spinal fluid. This fluid protects the central nervous system from concussions and mechanical injuries as well as being important to its metabolism. The brain and spinal cord are suspended in this hydraulic-like arrangement which acts as a liquid buffer equalizing pressure on all parts of the central nervous system.

The amount of the fluid is variable ranging from 80 to 100 c.c. on the average and sometimes as much as 150 c.c. is present.

In some pathological conditions the volume may be greatly increased or decreased. Internal hydrocephalus is the result of a great increase in the amount of cerebro spinal fluid. The volume of fluid normally increases in old age because of an increase in the size of the ventricles due to shrinkage of the brain tissue around these cavities.

It is a clear alkaline liquid, slightly sticky, salty taste, and a low specific gravity (1.004 to 1.008). It is about 98.5 per cent water, the remaining 1.5 per cent being animal and mineral material. It contains traces of proteins, small amounts of dextrose

and mineral salts. Its cellular content is limited to a few lymphocytes under healthy conditions.

ORIGIN OF THE CEREBRO-SPINAL FLUID

The cerebro-spinal fluid is being constantly renewed. Its primary source is the blood vessels of the choroid plexus in the ventricles of the brain, particularly those of the lateral ventricles. Lesser sources may be the local blood vessels of the brain and the pia mater.

CIRCULATION OF THE CEREBRO-SPINAL FLUID

From the lateral ventricles it passes through the interventricular foramina (of Monro) into the third ventricle where more fluid is added from the choroid plexuses of that ventricle. From the third ventricle it passes backwards through the cerebral aqueduct (Sylvius) into the fourth ventricle at which location still more fluid is added from the plexuses in its roof and lateral recesses. From the fourth ventricle it escapes into the subarachnoid space by the foramina of Luschka, one at the tip of each lateral recess, and by the foramen of Magendie located medially in the roof of the fourth ventricle. Having reached the subarachnoid space the fluid spreads slowly upwards to bathe all parts of the brain; it also passes downwards to fill the subarachnoid space around the spinal cord.

In the spinal subarachnoid space the direction of flow is essentially from above downwards and very little of the fluid leaving the fourth ventricle returns to this point except for that in the ascending current of the central canal of the spinal cord. The fluid is returned to the blood stream by two routes.

(1) Absorption of the cerebro-spinal fluid takes place chiefly into the specialized venous sinuses of the crainal dura mater by way of the arachnoid villi and Pacchionian bodies.

(2) In the spinal subarachnoid space much of the fluid is absorbed directly into the extensive network of veins making up the internal venous plexus and the remainder drains into lymphatic vessels located alongside the spinal nerve roots.

The absorption rate of the fluid is quite rapid; from the subarachnoid space into the bloodstream in ten to thirty seconds, and into the lymphatics in about thirty minutes.

FUNCTIONS OF CEREBRO-SPINAL FLUID

Its primary function is to provide nutrition to the nerve cells of the brain and the spinal cord. Also, the waste products of these cellular activities pass into the fluid and are removed by it. The fluid further has the important function of protection for the central nervous system.

BLOOD SUPPLY TO THE CORD

A. ARTERIES

There are three large longitudinal arteries running the entire length of the cord, one anterior spinal artery, and two posterior spinal arteries.

1. **Anterior Spinal Artery** arises from the union of two small branches off each vertebral artery at the level of the foramen magnum. It descends in front of the anterior median fissure as far down as the conus medullaris. Along its course the anterior spinal artery gives off a great number of small branches called **central arteries** which pass into substance of the cord and supply the nervous tissue of its anterior half.

The anterior spinal artery also receives numerous small tributaries which enter the vertebral canal through the intervertebral foramina; these branches are derived from the vertebral and ascending cervical arteries in the neck; from the intercostals in the thorax; and from the lumbar, ilio-lumbar and lateral sacral arteries of the abdomen and pelvis. These are the **lateral spinal arteries**, and each one lies alongside a spinal nerve near the external opening of an intervertebral foramen but upon approaching the cord they accompany corresponding nerve roots and become the anterior and posterior radicular (root) arteries.

2. **The two posterior spinal arteries**, one on each side, lie near the point of entry of the posterior nerve roots into the cord. These arteries also extend the longitudinal length of the cord, arising as a branch from the vertebral arteries above the level

of the foramen magnum. Each receives numerous branches from the radicular arteries.

The two posterior spinals communicate with each other by means of irregular transverse branches found at successive levels of their course.

The gray matter of the dorsal horns and its surrounding white substance are the structures mainly supplied by these two longitudinal vessels.

The extensive anastomosing of the anterior and posterior spinal arteries forms a **peripheral arterial plexus** which penetrates and supplies the white substance of the cord along its entire circumference. The pia mater also receives its rich blood supply from this source.

B. VEINS

The venous system is quite similar to the arterial as regards naming and course of vessels.

The veins of the spinal cord are six in number (1) two median longitudinal veins, one in front of the anterior fissure (anterior spinal vein), and the other behind the posterior sulcus (posterior spinal vein), and (2) four longitudinal veins which run behind the four spinal nerve roots.

These six vessels are collectively known as the **posterior and anterior external spinal veins** and they drain the nervous matter of the spinal cord through smaller veins located in the cord substance. At the periphery of the cord they form an extensive **peripheral venous plexus** supported by the pia mater.

This network communicates with the internal venous vertebral plexus and from this plexus blood is drained by radicular veins accompanying the anterior and posterior nerve roots. In turn the radicular veins empty into the **intervertebral veins** which pass out through the intervertebral foramina and end in the vertebral, intercostal, lumbar, and lateral sacral veins.

LYMPHATICS OF THE CORD

There are no lymphatics in the spinal cord. The cerebrospinal fluid and the blood fluids from the capillaries filter through

the nervous tissue of the cord and then enter the small perivascular spaces surrounding the blood vessels to drain outwards to the cord surface and empty into the subarachnoid space.

At this point it is indeed interesting to note that many of the described nutritional channels to the cord and its coverings are the results of recent anatomical discoveries. Until recent years it was generally assumed that many of the tissues making up the vertebral column and its contents were without means of direct nutritive supply, with the exception of Chiropractic philosophy which has long maintained that every body tissue cell receives needed nutrition by means of the serous circulation.

Chiropractic makes no claim to having discovered the blood system, nor the lymphatic system, nor the circulation of other related fluids, but it does claim to have been the first in science to correlate and integrate these systems as part of one general system of fluid nutrition to body cells. Undoubtedly, further anatomical research will substantiate this concept.

NERVES OF THE SPINAL CORD AND MENINGES

The dura mater and the pia mater both exhibit a rich supply of nerves. All the larger blood vessels of these meninges are surrounded by extensive nerve plexuses derived from the sympathetic system. Both medullated and non-medullated nerve fibers accompany the blood vessels into the substance of the spinal cord. Each level of the cord and its corresponding segment of meningeal coverings receives a direct meningeal nerve which branches from the beginning of a spinal nerve trunk and immediately reenters the intervertebral foramen.

PROTECTION OF THE SPINAL CORD

There are four chief provisions for the protection of the spinal cord.

(1) The bony walls of the vertebral canal encircle the delicate cord, and as these walls are made up of separate vertebrae held together by joint surfaces, movement is possible without compressing the enclosed spinal cord.

(2) The meninges serve to suspend the cord and to anchor it to the surrounding vertebral canal. By attachment of the dura mater to the ligaments and vertebrae of the spinal column, and through the stabilization afforded by the ligamenta denticulata, the spinal cord is held firmly in its normal position.

(3) The curves of the vertebral column along with the intervertebral discs serve to cushion shocks and jars that might otherwise injure the cord.

(4) The cerebro-spinal fluid and the fat content of the epidural space form protective barriers around the cord to provide an equal dispersal of pressure, particularly in the event that the cord area is subjected to a violent concussion of forces as in a fall or blow or other trauma.

Chapter 4

ANATOMY OF THE BACK

The back may be loosely defined as the posterior part of the body from the skull above to the pelvis below, and extending inward from the skin to include the spinal column and its attached muscles and fascia.

The bones, muscles, nerves, vessels, and other tissues of the back are responsible for the support and movements of the trunk as well as support and stabilization for the head. In fact, both the upper and lower extremities are largely dependent upon attachment to structures of the back for their harmonious integrated functions.

In considering the anatomy of the back, it is best to follow a definite approach, layer by layer, from the overlying skin inward to the vertebral column.

THE SUPERFICIAL FASCIA of the back forms part of a continuous sheet of areolar connective tissue that underlies the skin over the entire body, and contains a variable quantity of fat as well as the **cutaneous nerves** and **blood vessels**. The superficial fascia of the body is also known as the **tela subcutanea.**

In the cervical region, the superficial fascia of the back of the neck is fibrous, thick, tough, and firmly attached to the deep fascia. The superficial fascia of the upper dorsal region is also thick, tough, and adherent, while in the lower dorsal and lumbar regions it is less compact but is thicker and contains more fat and is divided into several layers, the innermost of which is adherent to the deep lumbodorsal fascia.

Cutaneous nerves—supply the skin overlying the back. They arise from the posterior primary divisions of the spinal nerves and approaching the skin divide into small medial branches and larger lateral branches. In the cervical region the cutaneous

nerves come from the third to the sixth cervical. The 12 thoracic nerves supply the skin over the dorsal and lumbar regions, while the upper three lumbars also give off cutaneous branches but they descend over the gluteal region.

From the level of the fourth cervical spinal nerve downward, the cutaneous branches tend to supply skin areas increasingly lower than the level of the corresponding nerve trunk so that the skin of the lumbar region is supplied by cutaneous nerves arising from lower thoracic spinal nerves.

Cutaneous blood vessels—are small and numerous. They accompany the cutaneous nerves, and arise from the ascending branch of the transverse cervical arteries in the neck; the intercostals in the dorsal region, and from the lumbar arteries in that area.

Lymph vessels—The lymph drainage of the cervical superficial fascia is into the deep cervical glands in the front of the neck. The upper dorsal region is drained by vessels terminating in the axillary glands; the lower dorsal and lumbar regions by vessels emptying into the inguinal glands.

THE DEEP FASCIA OF THE BACK—is thin and strong over the cervical and dorsal regions, but is thick, dense, and very strong in the lumbar area where it is called the posterior layer of the LUMBAR FASCIA. For convenience, the deep fascia of the back may be considered in two different areas: (1) cervical, and (2) lumbo-dorsal.

1. **The Deep Cervical Fascia or Fascia Colli**—forms an investing layer which envelops the neck as a whole and splits to enclose the sterno-mastoid and the trapezius muscles. It also gives off many septa from its deep surface, and these pass inward to cover the deep muscles, glands, trachea, esophagus, pharynx, and the large cervical nerves and blood vessels.

The investing fascia is a continuous tubular envelope attached superiorly to the superior nuchal line, external occipital protuberance, and body of the mandible. To the inferior it extends to the level of the clavicle where it becomes continuous with the pectoral fascia of the chest and the deltoid fascia over the shoulder; its medial inferior portion is continuous with the deep fascia of the dorsal region. At the back of the neck the fascia colli is attached to the ligamentum nuchae at the median line.

The divisions derived from the septa include various complex compartments; prevertebral fascia, pretracheal fascia, carotid sheath, nuchal fascia, suprapleural membrane, and buccopharyngeal fascia.

(a) The Prevertebral Fascia is of particular interest because of its relationship to the spinal column. It is the anterior portion of the extensive vertebral fascia which encloses the vertebral column and its muscles.

The cervical prevertebral fascia is a part of one long prevertebral fascial sheet extending from the skull to the coccyx on the anterior surface of the spinal column. The prevertebral cervical fascia covers the rectus capitis anterior, rectus capitis lateralis, longus capitis and longus cervicis muscles, and anchors to the tips of the cervical transverse processes. Above, it is attached to the styloid process, jugular process and basilar portion of the occiput; below, it continues down in front of the longus cervicis and upper thoracic vertebrae. Its lower portion is also extended forward to surround and invest the scalenus anterior, medius and posterior muscles. On the back of these muscles it forms part of a conical fibrous structure called SIBSON'S FASCIA which arches over the cupula of the lung. The forward extension around the front of the scalenus muscles becomes continuous with the endothoracic fascia at the level of the first rib. The lower part of the deep cervical fascia is also drawn out laterally on either side to enclose certain of the nerves making up the brachial plexus as well as the subclavian artery and vein. This prolongation passes out under the clavicle into the axilla as the axillary sheath.

(b) The Carotid Sheath—is another compartment derived from the fascia colli. It is of importance in a consideration of the fascia of the spinal region as it is connected to the prevertebral fascia, and lies in close relationship to the spinal column. The carotid sheath is a tube of fascia which encloses the carotid artery, internal jugular vein, and vagus nerve. It is attached posteriorly to the prevertebral fascia along the line of the tips of the transverse processes. Above, it is firmly attached to the skull, and below, in the root of the neck, it is attached to the sternum and first rib and finally fuses with the fibrous pericardium. The sympathetic nervous trunk is imbedded in the fascia of the posterior wall of the sheath, and the descendens hypoglossi nerve in its anterior wall.

(c) **The Nuchal Fascia** represents the cervical portion of the vertebral fascia, and is continuous below with the lumbodorsal fascia. It forms a series of fascial septa which form compartments for the many cervical muscles, each of which is separated from its neighbor by dense, fatty areolar connective tissue supporting blood vessels and nerves. The nuchal fascia is actually a subdivision of the fascia colli; being confined to the cervical region and covering these muscles located in an area behind the transverse processes of the cervical vertebrae.

2. **Lumbodorsal Fascia**—is a deep fascia of the back which forms the sheath of the sacrospinalis muscle in particular, as well as giving origin to many of the back muscles. In its strict sense, the lumbodorsal fascia may be considered as a subdivision of the vertebral fascia. Above, it is continuous with the fascia nuchal on the back of the neck, medially it is attached to the spinous processes of the thoracic and lumbar vertebrae and the medial crest of the sacrum. To the inferior it is joined to the iliac crests and the lateral sacral crests. Its lateral attachments in the thoracic region include the angles of the ribs and the intercostal fascia, and it is partly replaced by the serratus posterior inferior muscle in the lower thoracic region, whereas in the lumbar region, it is continuous laterally with the aponeurosis of the transversalis abdominis muscle. In the lumbar region, the lumbodorsal fascia is greatly thickened and forms the posterior layer of the lumbar fascia. Actually, the lumbar portion of the lumbodorsal fascia is designated as the **lumbar fascia** and this dense, glistening white fibrous membrane has three layers, posterior, middle, and anterior.

Posterior Layer of Lumbar Fascia—is very thick and strong, and covers the posterior surface of the lumbar portion of the sacrospinalis muscle. Laterally it fuses with the middle layers at the lateral border of the sacrospinalis.

Middle Layer of Lumbar Fascia—stretches downward from the twelfth rib to the iliac crest and the ilio-lumbar ligaments. It forms an intermuscular partition between the anterior surface of the sacrospinalis muscle and the posterior surface of the quadratus lumborum muscle. Medially it is attached to the tips of the lumbar transverse processes, and laterally it extends to the lateral borders of the sacrospinalis and quadratus lumborum where it fuses with both the anterior and posterior layers.

Anterior Layer of Lumbar Fascia—or the lumbocostal aponeurosis, also stretches from the last rib to the iliac crest and the ilio-lumbar ligament. It covers the front of the quadratus lumborum muscle and separates its medial part from the Psoas muscle. Its medial attachments are the anterior surfaces of the lumbar transverse processes. Its upper portion, attaching to the 12th rib and the transverse process of the first lumbar vertebra to the lateral arcuate ligaments of the diaphragm is named the **lumbo costal ligament.**

THE MUSCLES OF THE BACK

The musculature of the back is formed by a number of incompletely separated layers of muscles which may be distinguished from one another partly by the direction of their fibers, and partly by their lengths. The long muscles are placed superficially, the intermediate muscles more deeply, and the short muscles lie directly against the vertebrae. From the standpoint of function, there is little basis to subdivide the back musculature as it is obvious that all the spinal muscles work together to produce the movements of the spinal column. However, for descriptive purposes, the muscles of the back are generally subdivided into five main groups.

Group I—includes the TRAPEZIUS and LATISSIMUS DORSI; two muscles that form part of the musculature of the back, but in reality belong to the upper limb muscles. They connect the upper extremity to the vertebral column.
The Trapezius—is a flat, triangular muscle lying superficially on the back of the neck and the back of the upper part of the trunk.

Origin—external occipital protuberance, medial third of superior nuchal line, ligamentum nuchae, the spinous processes of the seventh cervical, and all 12 dorsals, and from the supraspinous ligaments.

Insertion—the superior fibers run downward and lateralward to the posterior border of the lateral third of the clavicle; the middle fibers insert into the medial surface of the acromian process and the superior lip of the spine of the scapula; the inferior fibers end in an aponeurosis inserted into the tubercle on the lower lip of the spine of the scapula.

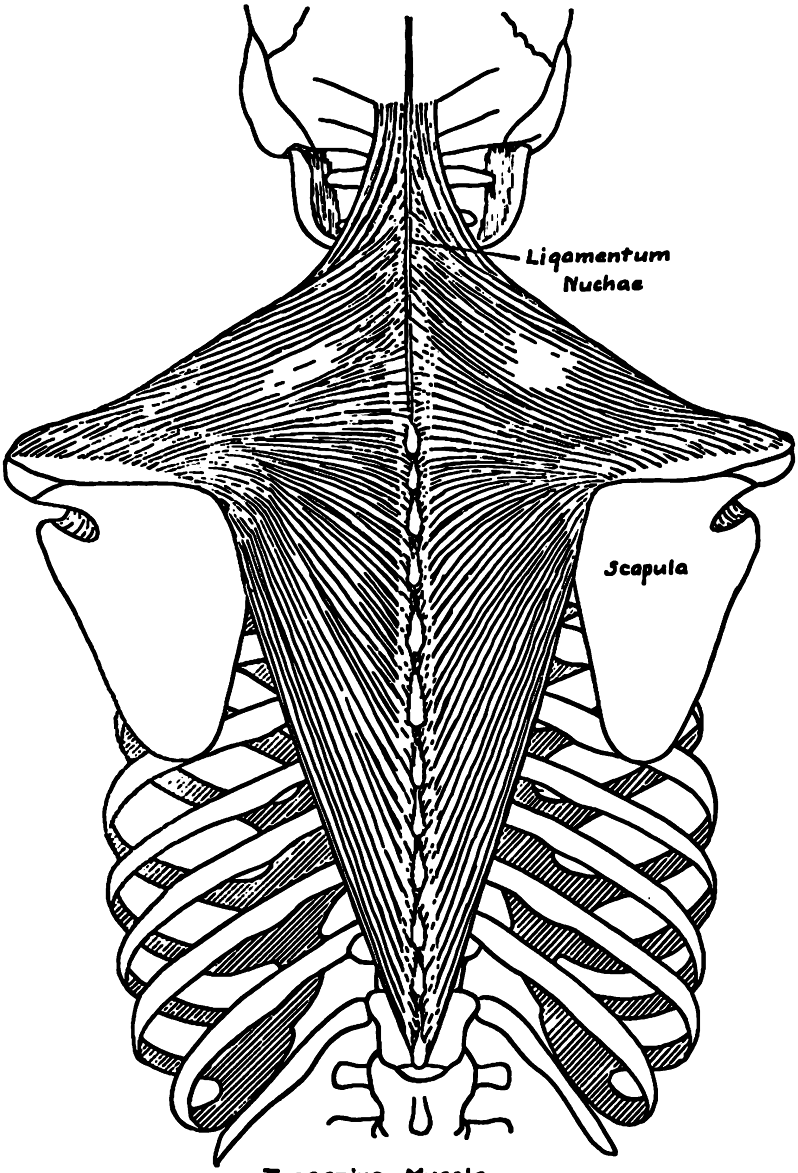


Fig. 47. Back muscles—group one.

Action—The whole trapezius muscle braces back the shoulder. The upper fibers raise and the lower fibers depress the shoulder. The middle and lower fibers help to rotate the scapula in the act of adducting the arm. When the shoulder is fixed, the upper fibers draw the head toward the same side and turn the face to the opposite side; both sides acting together draw the head directly backward.

Nerve Supply—Principal nerve supplying each half is the spinal accessory, and there are also branches of the anterior primary divisions of the third and fourth cervical nerves.

The Latissimus Dorsi—is a large triangular muscle that covers the lumbar region and the lower part of the posterior wall of the thorax and axilla.

Origin—is very broad, and chiefly tendinous by a broad aponeurosis from the posterior layer of the lumbodorsal fascia. It arises from the spinous processes of the lower six thoracic vertebrae under cover of the trapezius, from the spinouses of the lumbar and sacral vertebrae, from the posterior iliac crest, and by small fleshy slips from the lower three or four ribs. Occasionally, the upper part of the muscle also originates from the inferior angle of the scapula.

Insertion—by a flat tendon about three inches long inserted into the floor of the bicipital groove of the humerus. Some fibers pass into the deep fascia of the upper arm.

Action—The Latissimus Dorsi assists in drawing the trunk upward and forward. It can help in raising the lower ribs, but its most obvious action is to adduct and extend the arm and to rotate it medially. It also draws the shoulder downward and backward.

Nerve Supply—The nerve supply is by way of the long subscapular (thoracodorsal) nerve from the posterior cord of the brachial plexus, containing fibers from the sixth, seventh, and eighth cervical nerves.

The Triangle of Auscultation—is so-called because it is the only part of the ribs not covered by muscles. The triangle is bounded by the trapezius above, the latissimus dorsi below, and the vertebral border of the scapula laterally. When the arms are folded across the chest and the trunk is bent forward, parts of the sixth and seventh ribs and the sixth intercostal space are covered only by skin and superficial fascia.

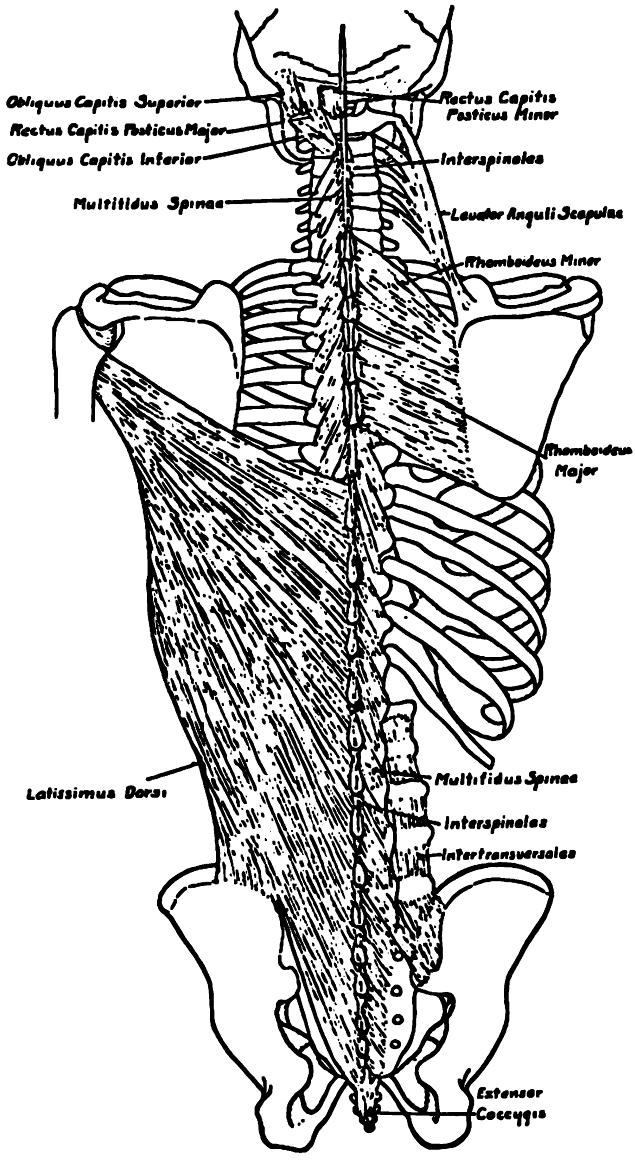


Fig. 48. Back muscles—groups mixed.

Group II—includes three muscles which also connect the upper extremity to the vertebral column. They all lie under cover of the trapezius muscle. The muscles of the second group include the LEVATOR SCAPULAE, RHOMBOIDEUS MAJOR, and RHOMBOIDEUS MINOR.

The Levator Scapulae—(Levator Anguli Scapulae) is situated at back of the side of the neck.

Origin—is by tendinous steps from the upper four cervical transverse processes.

Insertion—into the vertebral border of the scapula from the upper angle to the root of the spine. The muscle is split lengthwise into two parts, and the fibers of highest origin insert lowest on the scapula while those from the third and fourth cervical transverses insert higher up on the scapula.

Action—with the scapula fixed, it bends the neck laterally and rotates it slightly toward the same side. It assists the trapezius in raising the shoulder and bracing it against weights.

Nerve Supply—from the branches of the third and fourth cervical nerves of the cervical plexus directly, with some fibers from the fifth cervical by way of the dorsal scapular nerve (nerve to the rhomboids).

Rhomboideus Major—lies in the upper part of the back under cover of the trapezius.

Origin—from the second to the fifth thoracic spinous processes and the supraspinal ligament.

Insertion—by way of a fibrous band to the root of the scapula spine and the vertebral border of the scapula from the root of the spine to the inferior angle.

Action—to retract and rotate the scapula. Also assist in adduction of the arm by rotating the scapula downward.

Nerve Supply—the nerve to the rhomboids from the fifth cervical which nerve is also known as the dorsal scapular.

Rhomboideus Minor—lies in the upper part of the back immediately above the rhomboideus major and edge to edge with it.

Origin—from the lower part of the ligamentum nuchae and from the spinous processes of the seventh cervical and first thoracic vertebra.

Insertion—the vertebral border of the scapula at the root of the spine.

Action—retract and rotate the scapula.

Nerve Supply—dorsal scapular nerve.

Group III—This group includes four muscles; SPLENIUS CAPITIS, SPLENIUS CERVICIS, SERRATUS POSTERIOR SUPERIOR, AND SERRATUS POSTERIOR INFERIOR. The Splenius muscles make up part of the deep muscles of the back, and are concerned with movements of the head and neck. The serratus muscles, although located in the layers of back muscles and attached to the vertebrae, are active in respiration rather than in spinal movement. Anatomically, they are considered as muscles of the thorax. The splenius muscles are interesting in that their fibers arise medially and pass laterally as they ascend; which direction is in contrast with those followed by other back muscles which either run parallel to the spinal column or run toward it as they ascend. Because of the direction assumed by their fibers, the splenius muscles are sometimes included in the transverse-costal group, indicating origin on a spinous process and insertion on a transverse process. The Splenius Capitis and Splenius Cervicis muscles both have the same actions and nerve supplies.

Splenius Capitis—is a long, wide, muscular strap which lies on the back of the neck and the upper part of the thoracic region. It lies under the trapezius and the rhomboidei muscles.

Origin—the lower half of the ligamentum nuchae, spinous process of the seventh cervical vertebra, and spinous processes of the upper four thoracic vertebrae.

Insertion—into surface of occiput just below the lateral third of the superoir nuchal line, and also into the mastoid process of the temporal bone.

Splenius Cervicis or Splenius Colli.

Origin—from the spinous processes of the third to the sixth thoracic vertebrae.

Insertion—is into the transverse processes of the upper two to four cervical vertebrae. The insertion is beneath the origin of the Levator scapulae.

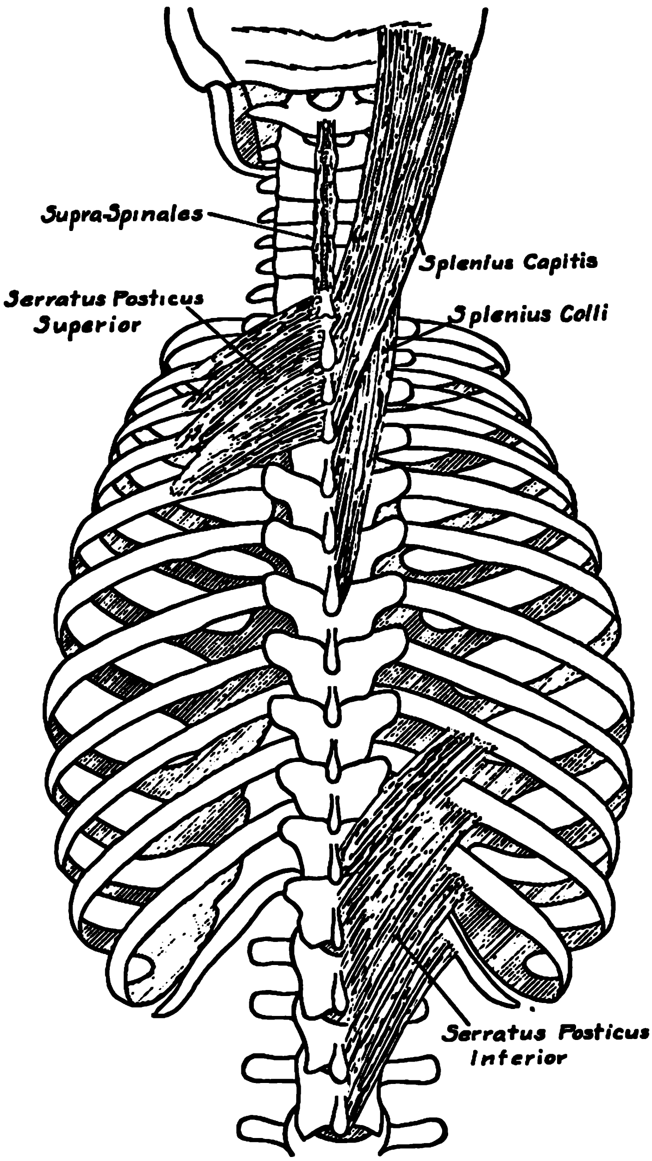


Fig. 49. Back muscles—groups mixed.

Action—Both muscles acting together extend the head and neck. The muscles of one side, acting together, bend the head and neck to that side, and turn the face toward that side.

Nerve Supply—is by way of the posterior primary divisions of the fourth to the eighth cervical nerves.

Serratus Posterior Superior—is a very thin muscle lying under cover of the rhomboid muscles.

Origin—from the lower part of the ligamentum nuchae, supraspinal ligament, and spinous processes of the seventh cervical and upper three thoracic vertebrae.

Insertion—into the upper borders of the second to the fifth ribs, slightly beyond their angles.

Action—to elevate the upper ribs in forced inspiration.

Nerve Supply—is by way of branches from the anterior primary divisions of the first four intercostal nerves.

Serratus Posterior Inferior—is also very thin, and it lies under cover of the latissimus dorsi at the junction of the thoracic and lumbar regions.

Origin—is from the spinous processes of the eleventh and twelfth thoracic and the first and second lumbar vertebrae.

Insertion—fibers run upward and lateralward to insert into the inferior borders of the lower four ribs, a little lateral to their angles.

Action—fixes the lower ribs when the diaphragm contracts, and it draws the ribs backward and downward in forced inspiration.

Nerve Supply—the branches of the anterior primary divisions of the ninth to twelfth intercostal nerves.

Group IV—This group of deep muscles of the back actually is represented by a single large muscle, the SACROSPINALIS, which divides into three columns. Because it arises for the most part from a medial origin and its fibers pass in a slightly lateral direction, this muscle is also included in the transverso-costal group, along with the Splenius capitis and Splenius cervicis.

The origin of the sacrospinalis muscle forms the heavy musculo-tendinous mass over the upper sacral and lower lumbar vertebrae. It lies in a groove on either side of the median line

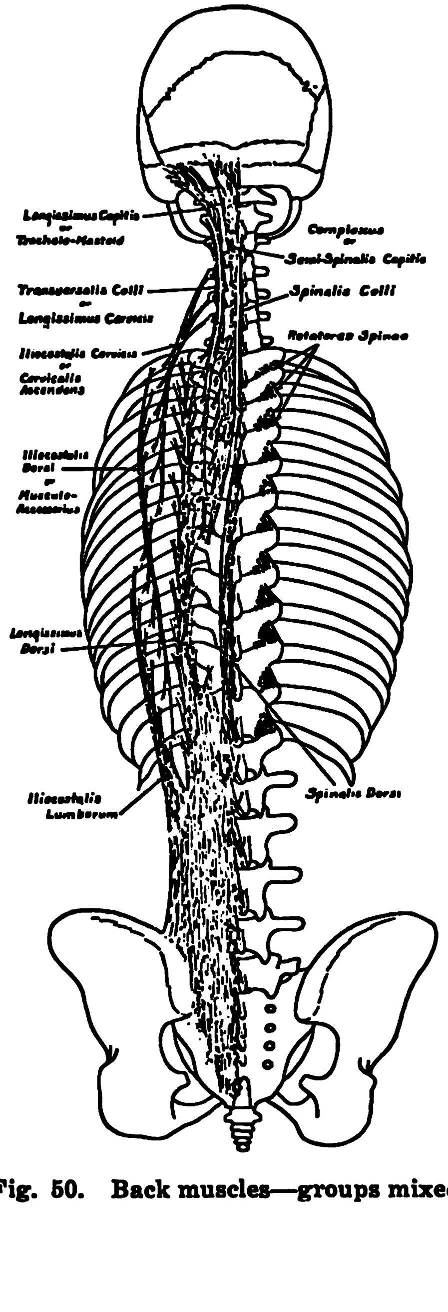


Fig. 50. Back muscles—groups mixed.

of the spinal column and in the lumbar and thoracic regions is covered by the lumbo-dorsal fascia; in the cervical region it lies under cover of the nuchae fascia.

As the Sacrospinalis or Erector Spinae ascends upwards, it divides into three columns which gradually diminish in size as they are inserted into the vertebrae and the ribs. These columns with their subdivisions are as follows:

Lateral Column Iliocostalis	Intermediate Column Longissimus	Medial Column Spinalis
I. Lumborum	L. Dorsi	S. Dorsi
I. Dorsi	L. Cervicis	S. Cervicis
I. Cervicis	L. Capitis	S. Capitis

I. Iliocostalis—is the most lateral upward continuation of the sacrospinal muscle, and is subdivided into three linear, but overlapping portions, the iliocostalis lumborum, the iliocostalis dorsi, and the iliocostalis cervicis.

Iliocostalis Lumborum—or Sacro Lumbralis Muscle

Origin—in common with the origin of the sacrospinalis.

Insertion—by tendinous slips into the inferior borders of the angles of the lower six or seven ribs.

Iliocostalis Dorsi

Origin—by flat tendons from upper borders of the angles of the six lower ribs.

Insertion—into the upper borders of the angles of the upper six ribs, and the posterior surface of the transverse process of the seventh cervical vertebra.

Iliocostalis Cervicis or Iliocostalis Colli

Origin—from the angles of the third, fourth, fifth, and sixth ribs medial to the iliocostalis dorsi.

Insertion—into the transverse processes of the fourth, fifth, and sixth cervical vertebrae.

Action—acting together, the iliocostalis muscles extend the vertebral column. One side acting alone bends it to one side. The lumborum and dorsi draw the ribs downward.

Nerve Supply—branches of the posterior primary divisions of the spinal nerves.

II. **Longissimus** is the intermediate, and the longest of the columns of the sacrospinalis. Like the iliocostalis muscle, it is composed of three divisions which so overlap each other that the muscle has attachment upon almost every vertebral segment. The three divisions of the longissimus are: longissimus dorsi, longissimus cervicis, and longissimus capitis.

Longissimus Dorsi

Origin—through common tendons with iliocostalis and spinalis from the spinous processes of sacrum and lumbar vertebrae.

Insertion—into the transverse and accessory processes of lumbars, all the thoracic transverse processes, and into the lower ten ribs between their tubercles and angles.

Longissimus Cervicis or Longissimus Colli is also known as the Transverse cervical muscle. It is situated medial to the Longissimus dorsi.

Origin—by long, thin tendons from the transverse processes of the upper six thoracic vertebrae.

Insertion—by long tendons into the second to the six cervical transverse processes.

Longissimus Capitis or Trachelo Mastoid Muscle lies between the Longissimus cervicis and the Semispinalis capitis.

Origin—from the transverse processes of the four to six thoracic vertebrae, and the articular processes of the lower four cervical vertebrae.

Insertion—mastoid process.

Action—the dorsi and cervicis acting together extend the vertebral column and bend it to one side when one lateral half of the muscles contract. The longissimus capitis extends the head; the muscle of one side acting alone bends the head to the same side and rotates the face toward that side.

Nerve Supply—is by branches of the posterior primary divisions of the spinal nerves corresponding to the areas of the muscle.

III. Spinalis Muscle is the medial division of the sacrospinalis, and is almost always poorly developed. It is situated medial to the Longissimus muscle and is usually blended with it.

Spinalis Dorsi

Origin—by means of three of four tendons from the spinous processes of the lower two thoracic and upper two lumbar vertebrae.

Insertion—into the spinous processes of the upper six thoracic vertebrae.

Spinalis Cervicis or Spinalis Colli is not always present.

Origin—from spinous processes of upper two thoracic and the seventh cervical vertebrae.

Insertion—is into the spinous processes of axis and the third cervical.

Spinalis Capitis—is inseparably fused with Semispinalis capitis muscle.

Action of the Spinalis Muscle—is to extend the vertebral column.

Nerve Supply of the Spinalis Muscle—branches of the posterior primary divisions of the spinal nerves corresponding to the areas of the muscle.

Group V—The fifth group includes deep muscles of the back with fibers running mainly upward and medially, and is sometimes referred to as the **Transverso-Spinal Group** because for the most part these muscles course from transverse processes to spinous processes. The transverso-spinal muscles include the following:

Semispinalis
Multifidus
Rotatores
Interspinales
Intertransversarii

Also included in the fifth group are the **Sub-Occipital Muscles.**

Rectus Capitis Posterior Major
Rectus Capitis Posterior Minor
Obliquus Capitis Superior
Obliquus Capitis Inferior

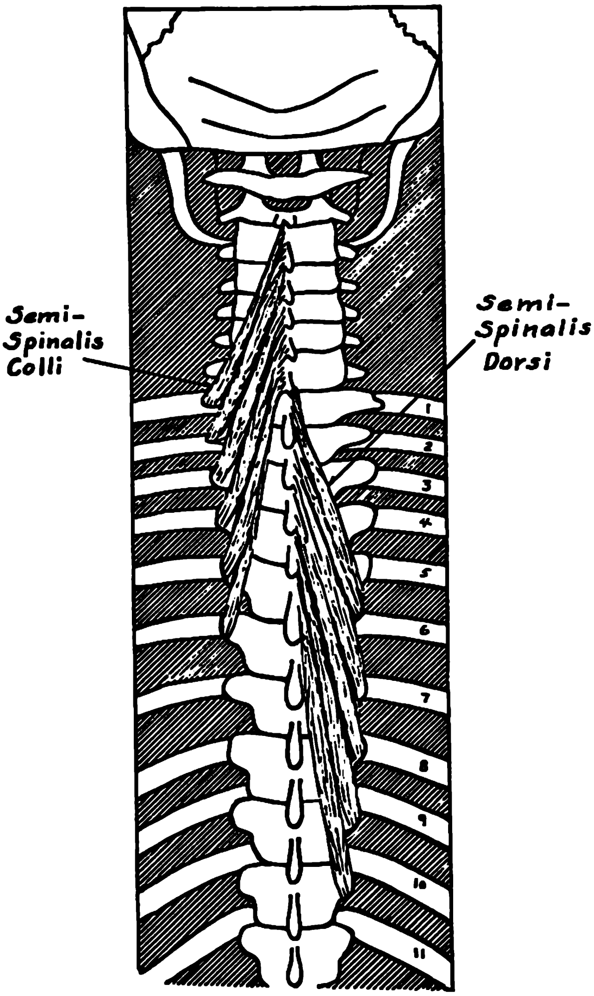


Fig. 51. Back muscles—part of the transverso-spinal group.

The muscles of the fifth group share the common property of being relatively short muscles whereas the muscles of the fourth group, SACROSPINALIS, are of greater length.

The Semispinalis is divided into the Semispinalis dorsi, Semispinalis cervicis, and Semispinalis capitis. It may be seen as a deeper, more continuous set of fibers beneath the Sacrospinalis muscle.

Semispinalis Dorsi

Origin—by tendinous slips from the transverse processes of the lower six thoracic vertebrae.

Insertion—into the spinous processes of the upper four thoracic vertebrae and lower two cervical vertebrae.

Semispinalis Cervicis or Semispinalis Colli is a thick mass of muscle lying under cover of the Semispinalis capitis.

Origin—by a series of tendons from transverse processes of upper six thoracic vertebrae.

Insertion—mainly into spinous process of axis with some tendons inserting into third, fourth, and fifth, cervical spinous processes.

Action—extends the vertebral column and rotates it toward the opposite side.

Semispinalis Capitis or Complexus Muscle is a thick, powerful muscle. It lies along the median plane in the back of the neck and the upper part of the trunk, under cover of the trapezius and Splenius, and medial to the Longissimus capitis and cervicis.

Origin—from tips of transverse processes of upper six thoracic vertebrae, transverses of the seventh cervical, and the articular processes of the fourth, fifth, and sixth cervical vertebrae.

Insertion—into the medial half of the area between the superior and inferior nuchal lines. The inner portion of the muscle is sometimes considered as being a separate muscle known as the Biventer Cervicis

Action—The Semispinalis Capitis muscles acting together extend the head. One muscle acting singly rotates the head toward the opposite side.

Nerve Supply—all divisions of the Semispinalis muscle are innervated by the posterior primary divisions of the spinal nerves corresponding to the areas of the muscle.

The Multifidus or Multifidus Spinae lies deep to the Semispinalis which it resembles except that its fibers are shorter, being only two to four vertebrae in length, and thus it runs more obliquely to the spinal column than does the Semispinalis. The multifidus consists of a number of muscular and tendinous bands which fill up the groove on either side of the spinous processes of the vertebrae, from the sacrum to the axis.

Origin—from the back of the sacrum alongside the spinous tubercles, from the overlying tendon of the Sacrospinalis muscle, from the lumbar mamillary processes, from the thoracic transverse processes, and the articular processes of the lower four cervical vertebrae.

Insertion—into the spinous processes of all lumbar, thoracic, and cervical vertebrae except atlas and axis. Most sections of the muscle run the length of two vertebrae, some extend as far as four or five vertebrae before inserting.

Action—is to extend the vetrebral column and rotate it toward the opposite side.

Nerve Supply—the branches of the posterior primary division of the spinal nerves corresponding to the areas of the muscle.

The Rotatores or Rotatores Spinae are especially well developed in the thoracic region, and lie deep to the multifidus. In fact, they form the deepest layer of muscles in the groove between the spinous and transverse processes, and are found along the entire length of the vertebral column from the sacrum to the axis. There are two groups—the long, and the short rotators. The long pass from one vertebra to the second above, whereas the short pass from one vertebra to the next above.

Origin—from the transverse process of a vertebra.

Insertion—the base of the spinous process next above.

Action—acting bilaterally together, they extend the vertebral column, and, acting unilaterally, they rotate it toward the opposite side.

Nerve Supply—branches of the posterior primary divisions of the spinal nerves corresponding to the areas of the muscle.

The Interspinales are all short muscles connecting adjacent spinous processes. In the **Cervical Region** they are strong and well developed, and are made up of six pairs, the first being between axis and third cervical, and the last between the seventh cervical and first thoracic spinous processes. In the **Thoracic Region**, they are usually absent except between the first two and last two vertebrae. In the **Lumbar Region**—there are four pairs between the five lumbar spinouses.

Action—is to extend the spinal column.

Nerve Supply—branches of the posterior divisions of the spinal nerves corresponding to the areas of the muscle. Sometimes, an extension of the interspinalis of the sacrum and coccyx is known as the **Extensor Coccygis**. In man, the muscle is a rudiment of the Extensor muscle seen in certain lower animals.

Intertransversarii are small muscles running between adjacent transverse processes. They are poorly developed or absent in the thoracic region, but are double in the lumbar region where there are medial and lateral intertransversarii, and in the cervical region where there are anterior and posterior ones.

In the **Cervical Region** they are best developed, and are placed in pairs between the transverse processes of two adjoining vertebrae. Between each anterior and posterior pair is a groove which transmits the anterior primary division of a cervical nerve. There are seven pairs of these muscles, the first pair being between the atlas and axis, and the last pair between the seventh cervical and first thoracic vertebrae.

In the **Lumbar Region**—they are also arranged in pairs between the transverse processes of the lumbar vertebrae. The medial intertransversarii arise from the accessory process of one vertebra and insert into the mammillary process of the vertebra next below. The lateral intertransversarii run from one transverse process to the next below.

Action—the intertransversarii muscles bend the vertebral column laterally, and when acting on both sides, make it rigid.

Nerve Supply—branches of the posterior primary divisions supply the medial group; branches of the anterior primary divisions of the spinal nerves supply the anterior, posterior, and lateral intertransversarii muscles.

THE SUBOCCIPITAL MUSCLES—two recti and two obliquii; they lie deep in the uppermost part of the back of the neck, under cover of the Splenius and Semispinalis capitis. Each is a short, well-developed muscle for movements of the atlanto-occipital and atlanto-axial joints.

Rectus Capitis Posterior Major

Origin—by a tendon from the spinous process of axis.

Insertion—into the lateral part of the space between the inferior nuchal line and the foramen magnum, and the lateral part of the inferior nuchal line.

Action—Both acting together extend the head. One acting alone turns the face to the same side.

Nerve Supply—a branch of the posterior primary division of the first cervical or suboccipital nerve.

Rectus Capitis Posterior Minor is a very small, fan-shaped muscle. It lies medial to the major and is partly covered by it.

Origin—by a narrow tendon from the tubercle on the posterior arch of atlas.

Insertion—medial part of the space between the inferior nuchal line and the foramen magnum.

Action—tilts the head backward.

Nerve Supply—a branch of the posterior primary division of the suboccipital nerve.

Obliquus Capitis Superior—is narrow below and wide above.

Origin—upper surface of the atlas transverse process.

Insertion—in the lateral part of the space between the superior and inferior nuchal lines.

Action—to bend the head backward and laterally to the same side as the acting muscle.

Nerve Supply—a branch of the posterior primary division of the suboccipital nerve.

Obliquus Capitis Inferior—is larger than the Obliquus superior.

Origin—spinous process of axis.

Insertion—transverse process of atlas.

Action—is to rotate the atlas and so turn the face to the same side as the acting muscle.

Nerve Supply—a branch of the posterior primary division of the suboccipital nerve.

The two rectus muscles aid in extension of the head at the atlanto-occipital joint; the obliquus inferior rotates the atlas with the head on the axis and helps to flex this region laterally, and the obliquus superior aids in extension and in the limited lateral flexion and rotation present at the atlanto-occipital joint. Three of these four muscles on each side of the upper cervical region form the sides of a suboccipital triangle; an important landmark in anatomy.

THE SUBOCCIPITAL TRIANGLE—is placed deeply at the uppermost part of the back of the neck. Its boundaries are:

Obliquus inferior, below and laterally.

Obliquus superior, above and laterally.

Rectus major, medially and somewhat above.

The roof is formed by the Splenius capitis laterally, and the semispinalis capitis medially; beneath these two muscles is a layer of dense fibro-fatty tissue. The floor is formed by the posterior arch of the atlas and the posterior occipito-atlantal membrane.

The suboccipital triangle contains the following:

1. Vertebral artery.
2. Posterior primary division of the suboccipital nerve.
3. The suboccipital plexus of veins.

THE ANTERIOR AND THE LATERAL VERTEBRAL MUSCLES

Besides the posterior muscles of the back, there are several other muscles which act directly upon the spinal column and are located at the anterior and the lateral surfaces of the column. These are divided into two main groups: the anterior vertebral muscles and the lateral vertebral muscles.

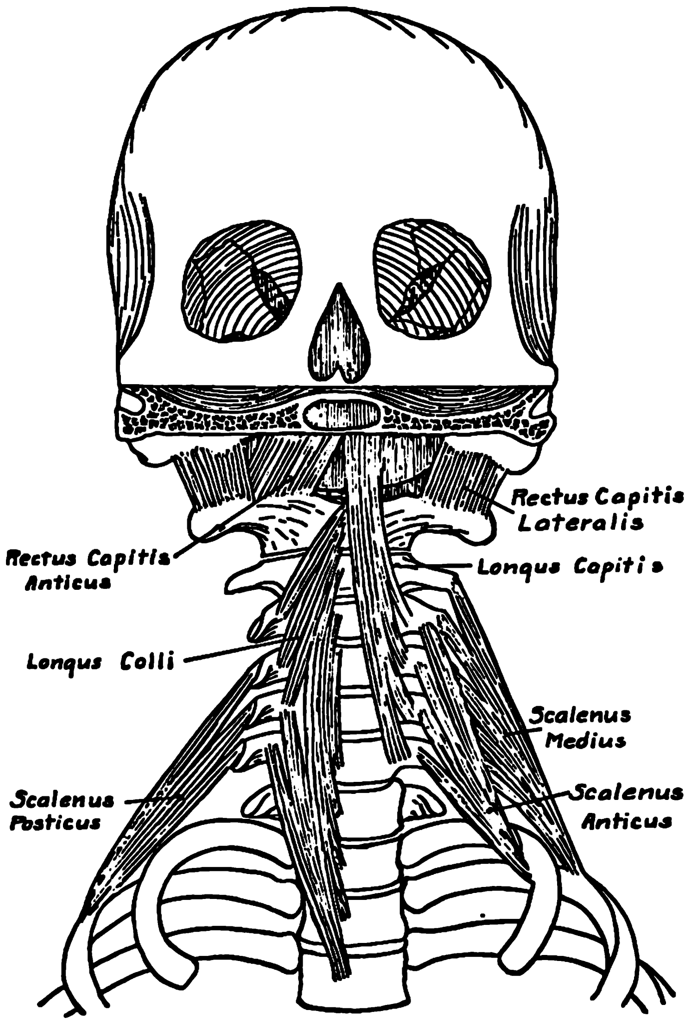


Fig. 52. Anterior vertebral group—cervical region.

I. The Anterior Vertebral or Prevertebral Muscles include the following:

1. Longus Colli
2. Longus Capitis
3. Rectus Capitis Anticus
4. Rectus Capitis Lateralis
5. Psoas Major
6. Psoas Minor
7. Quadratus Lumborum

The Longus Colli or Longus Cervicis—both arises and inserts into the anterior surfaces of the cervical vertebrae. It is narrow at each end and broad in the center, and is divided into three portions according to the direction of its fibers; the superior oblique portion, the inferior oblique portion, and the vertical or medial portion.

The superior oblique portion:

Origin—transverse processes of the third, fourth, and fifth cervical vertebrae.

Insertion—tubercle on the anterior arch of atlas.

The inferior oblique portion: is the smallest part of the muscle.

Origin—from front of bodies of first three thoracic vertebrae.

Insertion—into transverse processes of the fifth and sixth cervical vertebrae.

The vertical portion:

Origin—from the front of the bodies of the lower three cervical and upper three thoracic vertebrae.

Insertion—is into the front of the bodies of the second, third, and fourth cervical vertebrae.

Action of Longus Colli—to flex the neck forward and help rotate the cervical portion of the vertebral column. The superior oblique portion, acting on one side only tends to bend the neck toward that side and to rotate it toward the same side. The inferior oblique portion serves to prevent hyperextension of the cervical region, and also helps to rotate the neck slightly toward the opposite side.

Nerve Supply—by way of branches from the anterior divisions of the second to the seventh cervical nerves.

Longus Capitis or Rectus Capitis Anticus Major—lies in front of the upper cervical vertebrae and is thick and broad above, narrow below.

Origin—by four tendinous slips from anterior tubercles of transverse processes of third, fourth, fifth, and sixth cervical vertebrae.

Insertion—the inferior surface of the basilar part of the occipital bone, anterior and lateral to the pharyngeal tubercle.

Action—is to flex the head forward; one side acting alone turns the head toward that side.

Nerve Supply—branches from the anterior primary divisions of the first four cervical nerves.

Rectus Capitis Anterior or Rectus Capitis Anticus Minor—is a short, flat muscle lying behind and lateral to the Longus capitis.

Origin—the anterior surface of the lateral mass of atlas.

Insertion—the inferior surface of the basilar part of the occipital bone just in front of the foramen magnum.

Action—to flex the head forward.

Nerve Supply—branches from the anterior primary division of the first and second cervical nerves.

Rectus Capitis Lateralis—is included as a member of the anterior vertebral group because its nerve supply is from the anterior primary division of a spinal nerve.

Origin—the upper surface of the transverse process of the atlas.

Insertion—the lower surface of the jugular process of the occipital bone.

Action—bends the head laterally.

Nerve Supply—branches of the anterior primary division of the first cervical nerve.

Anterior to the Rectus capitis lateralis is the internal jugular vein.

Posterior to it lies the Obliquus capitis superior.

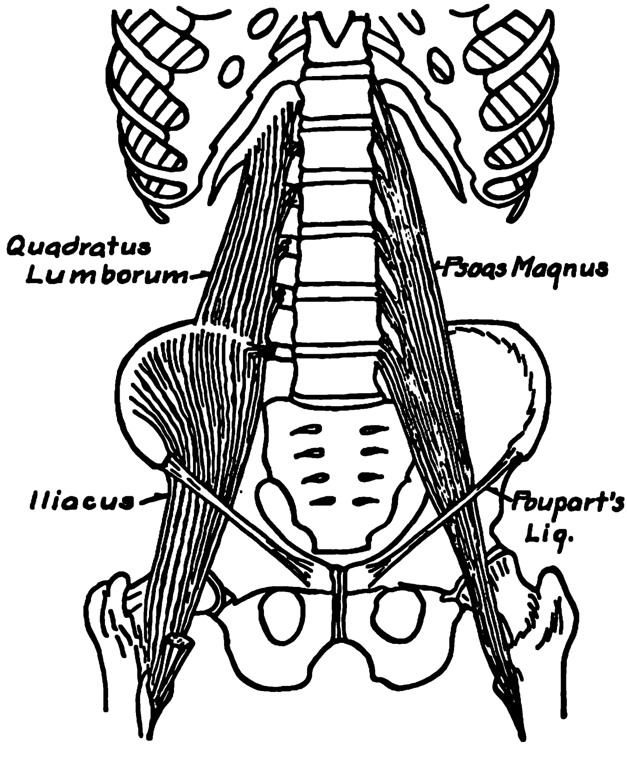


Fig. 53. Anterior vertebral group—lumbar region.

Lateral to it are the occipital artery and the posterior belly of the Digastric muscle.

Medial to it are the vertebral arteries, and the atlanto-occipital joint.

THE PSOAS MAJOR, PSOAS MINOR, AND THE QUADRATUS LUMBORUM are classified as muscles of the posterior abdominal wall; but all have a direct action upon the vertebral column, and all three are attached to the lumbar region: for these reasons, they may be properly considered as spinal muscles. Psoas Major or Psoas Magnus—is a long thick muscle which lies alongside the lumbar vertebral bodies on the front of the transverse process. It overlaps part of the Quadratus lumborum.

Origin—from the transverse processes of all the lumbar vertebrae, the intervertebral discs between the lumbar vertebrae, and the antero-lateral aspects of the bodies of the 12th thoracic and all the lumbar vertebrae.

Insertion—by a tendon into the greater trochanter of the femur.

Action—the Psoas major muscle flexes the lumbar portion of the vertebral column and bends it laterally. When the lumbar vertebral column is partially flexed, the psoas muscle will aid in its continued flexion by reversing its origin or fixed points, and will pull from below. This muscle is particularly concerned in raising the body to a sitting position from a supine position—in other words, to pull the lumbar region forward.

Nerve Supply—by way of branches from the lumbar plexus, particularly the 2nd, 3rd, and 4th lumbar nerves. Some fibers also are derived from the femoral nerve.

Psoas Minor or Psoas Parvus—is absent in nearly 40 per cent of the cases. It lies on the anterior surface of the Psoas major.

Origin—from the lateral margins of the 12th thoracic and 1st lumbar vertebral bodies, and the intervening disc.

Insertion—by means of a long tendon into pectineal line.

Action—helps flex the lumbar vertebral column.

Nerve Supply—directly by the 1st lumbar nerve.

Quadratus Lumborum—lies alongside the tips of the transverse processes of the lumbar vertebrae, enclosed between the anterior

and middle layers of the lumbar fascia. Behind it is the Sacrospinalis muscle, and in front of it is the Psoas major.

Origin—Lower lumbar transverse processes, the ilio-lumbar ligament, and the iliac crest adjacent to the ligament.

Insertion—is into the transverse processes of the upper four lumbar vertebrae, and the lower border of the 12th rib.

Action—flexes the lumbar vertebral column laterally toward the side of the contracting muscle. It also helps to extend the lumbar column when both muscles are acting together.

THE LATERAL VERTEBRAL MUSCLES include the following:

1. Scalenus Anterior
2. Scalenus Medius
3. Scalenus Posterior

The three muscles making up this lateral vertebral group form a triangular mass extending from the first two ribs upward to the transverse processes of the cervical vertebrae. In front of the group lies the prevertebral musculature, and behind it lies the deep spinal muscles. All of the lateral vertebral muscles are concerned with bending the neck forward and laterally, and rotate it toward the opposite side. When both sides are fixed, they steady the neck as in carrying a weight upon the head.

Scalenus Anterior or Scalenus Anticus—lies under cover of the sterno-cleido-mastoideus.

Origin—the anterior tubercles of the 3rd, 4th, 5th, and 6th cervical transverses.

Insertion—scalene tubercle of the first rib.

Action—bends the neck to the side contracting, and both muscles acting, flex the neck slightly.

Nerve Supply—anterior primary division of the 4th, 5th, 6th, and 7th cervical nerves.

Scalenus Medius—lies behind the Scalenus anterior and is the largest and longest of the group.

Origin—the posterior tubercles of the first through the seventh cervical transverse processes.

Insertion—by a broad attachment into the upper surface of the first rib alongside the scalene tubercle.

Action—bends the neck laterally, and slightly rotates it.

Nerve Supply—branches of the anterior primary divisions of the 3rd to the 7th cervical nerves.

Scalenus Posterior or Scalenus Posticus—lies behind the Scalenus medius and is frequently blended with it. It is the smallest muscle of the three.

Origin—posterior tubercles of 4th, 5th, and 6th cervical transverse processes.

Insertion—upper and lateral border of the second rib.

Action—the Scalenus posterior bends the neck laterally, and slightly rotates it.

Nerve Supply—branches of the anterior primary divisions of the 5th, 6th, and 7th cervical nerves.

MUSCLES ATTACHED TO THE VERTEBRAE

Bodies

1. **Longus Colli**—2nd to 7th Cervical, 1st to 3rd Thoracic.
2. **Psoas Major**—12th Thoracic, 1st to 5th Lumbar.
3. **Psoas Minor**—12th Thoracic, 1st Lumbar.

Laminae

1. **Rotatores Spinae**—1st to 11th Thoracic.

Articular Processes

1. **Longissimus Capitis**—4th to 7th Cervical.
2. **Semispinalis Capitis**—4th to 7th Cervical.
3. **Semispinalis Colli**—4th to 7th Cervical.
4. **Multifidus**—4th to 7th Cervical and 1st to 5th Lumbar.

Transverse Processes

1. **Obliquus Capitis Superior**—Atlas
2. **Obliquus Capitas Inferior**—Atlas.

3. **Rectus Capitis Lateralis**—Atlas.
4. **Levator Anguli Scapulae**—1st to 4th Cervical.
5. **Splenius Colli**—1st to 4th Cervical.
6. **Intertransversalis**—1st Cervical to 5th Lumbar.
7. **Longissimus Colli**—Axis to 6th Cervical, and 1st to 6th Thoracic.
8. **Longus Capitis**—3rd to 6th Cervical.
9. **Longus Colli**—3rd to 6th Cervical.
10. **Scalenus Anterior**—3rd to 6th Cervical.
11. **Scalenus Medius**—1st to 6th Cervical.
12. **Scalenus Posterior**—4th to 6th Cervical.
13. **Levatores Costarum**—7th Cervical, 1st to 11th Thoracic.
14. **Longissimus Capitis**—1st to 6th Thoracic.
15. **Longissimus Dorsi**—1st to 12th Thoracic, 1st to 5th Lumbar.
16. **Semispinalis Capitis**—1st to 6th Thoracic.
17. **Semispinalis Colli**—1st to 6th Thoracic.
18. **Multifidus**—1st to 12th Thoracic.
19. **Rotatores Spinae**—2nd to 12th Thoracic.
20. **Psoas Major**—1st to 5th Lumbar.
21. **Quadratus Lumborum**—1st to 5th Lumbar.

Spinous Processes

1. **Obliquus Capitis Inferior**—Axis.
2. **Rectus Capitis Posterior Minor**—Axis.
3. **Semispinalis Colli**—2nd to 5th Cervical.
4. **Spinalis Colli**—2nd to 4th Cervical, 7th Cervical, 1st and 2nd Thoracic.
5. **Interspinales**—Axis to 5th Lumbar.
6. **Multifidus**—Axis to 5th Lumbar.

7. **Semispinalis Dorsi—6th and 7th Cervical, 1st to 4th Thoracic.**
8. **Rhomboideus Major—2nd to 5th Thoracic.**
9. **Rhomboideus Minor—7th Cervical, 1st Thoracic.**
10. **Splenius Capitis and Colli—7th Cervical, 1st to 5th Thoracic.**
11. **Trapezius—7th Cervical, 1st to 12th Thoracic.**
12. **Spinalis Dorsi—4th to 8th Thoracic, 11th and 12th Thoracic, 1st and 2nd Lumbar.**
13. **Sacrospinalis—1st to 5th Lumbar, 1st to 3rd Sacral.**
14. **Serratus Posterior Superior—7th Cervical, 1st to 3rd Thoracic.**
15. **Serratus Posterior Inferior—11th and 12th Thoracic, 1st to 3rd Lumbar.**

Chapter 5

DYNAMICS OF THE VERTEBRAL COLUMN

The spinal column and its neuromuscular relations constitute a functional unit. In the normal human column, there is a balanced, dynamic, muscle, bone, and nervous integration which permits normalcy of movement, as well as giving the body symmetry. Considering the movements of the vertebral column from a mathematical standpoint, the intricacy and complexity of spinal motions is beyond human comprehension. For example, with only thirteen pairs of spinal muscles under study, there are more than sixty-seven million possible muscle combinations of movement. Since there are at least one hundred forty-four muscles directly attached to the movable spinal column, the mind is unable to conceive of such a staggering result as obtained by multiplying out to the one hundred and forty-fourth power. It becomes obvious that proper movement of the vertebral column can only be carried out to proper efficiency by the harmonious coordination of a nervous system free of interference, normal bony formation and arrangement of the vertebrae, and normal, healthy spinal musculature. Since the nervous system is the prime controlling factor of voluntary muscle, it follows that the outstanding requisite for spinal movement is complete integration of this system if such movement is to be smooth and harmonious. Otherwise, chaotic muscle antagonism will result in abnormal spinal dynamics, as well as malfunction and pathology of the muscular and bony components.

The functions of the vertebral column are manifold; it forms the axis of the skelton, supports the head, supports the walls and viscera of the trunk, acts as a shock absorber, and performs other important functions. One of its outstanding attributes is that of flexibility. Although movements between two adjacent vertebrae may be slight, the variety and the range of movements for the column as a unit are pronounced. The kinds of movement

permitted in the vertebral column are flexion, extension, lateral flexion, circumduction, and rotation.

In **Flexion**, or movement forward in the median plane, the anterior longitudinal ligament is relaxed, and the intervertebral discs are compressed in front, while the discs are stretched in their posterior portions. Also, under stretch are the posterior longitudinal ligaments, the ligamenta flava, and the interspinal and supraspinal ligaments. The most important factor in limiting flexion is tension of the extensor muscles of the back.

In spinal flexion, the spaces between the laminae are widened, and the inferior articular surfaces glide upward upon the superior articular surfaces of the vertebra next below. Flexion is the most extensive of all movements of the spinal column; is freest in the cervical region, and is relatively free in the lumbar region. However, in the thoracic region, flexion is limited because of the absence of an upward inclination of the superior articular surfaces. In the cervical region, flexion between the axis and third cervical is somewhat less than that between other cervical vertebrae due to the shallow intervertebral disc between these two vertebrae and the overhang of the anterior inferior lip of the axis body which mechanically checks forward flexion in this immediate area. This anatomical arrangement also applies to other cervical vertebrae, but to a lesser degree. Lumbar flexion is free because of the wide vertebral bodies and the thick intervening fibrocartilage discs. Another factor is the convex forward curve of this region, which type of curve also helps account for freedom of flexion in the cervical region.

In **Extension**, or backward movement in the median plane, the intervertebral discs are compressed behind, and stretched at their anterior longitudinal ligament, and by the approximation of the spinous processes. In the **cervical region**, extension can be carried farther than flexion. The upward inclination of the superior articular surfaces, combined with the small vertebral bodies and relatively thick intervertebral discs, permits extensive backward movement. Cervical extension in the atlanto-occipital region is limited somewhat by the locking of the posterior superior edges of atlas lateral masses in the condyloid fossa of the occipital bone. Between the seventh cervical and first thoracic extension is checked by the inferior articular processes of

the seventh cervical, stepping into grooves located behind and below the superior articular processes of the first thoracic. In the thoracic region, extension is very limited, being checked by the contact of the spinous processes with one another, and by the contact of the inferior articular margins with subjacent laminae. In the lumbar region, extension is free, and has greater range than flexion. This is especially so between the third and fourth, and the fourth and fifth lumbar vertebrae.

In Lateral Flexion there is movement away from, or toward, the median plane. The sides of the intervertebral discs are compressed, and the amount of motion lateralward is further limited by the tension put on the surrounding ligaments. Lateral flexion is possible in all regions of the spinal column, but is greatest in the cervical and lumbar regions. In the cervical region, lateral flexion is accompanied by a slight rotation due to the upward and medial inclination of the superior articular surfaces of the cervical vertebrae. In the thoracic region, flexion is limited by the rigidity of the attached rib cage. In the lumbar region, there is free lateral flexion because of the large spaces between the inferior articular processes of one vertebra and the superior articular processes of the vertebra next below.

Circumduction—is movement around a central axis in which one point of the spinal column remains fixed, and its opposite end describes a circular motion. For example, the rotation of the trunk in a wide circle around the fixed lumbar and pelvic regions. Circumduction is a combination of flexion, lateral flexion, and extension.

Rotation—is the movement of the spinal column around its central axis. It is accompanied by a twisting or torsion of the intervertebral fibrocartilages, and although rotation is slight between any two adjacent vertebrae, it becomes a considerable movement when taking place throughout the entire spinal column. In its true sense, rotation is a horizontal movement around a vertical axis. Rotation in the cervical region is free and may be considered as through 90 degrees to either side from the midline. It is combined with some lateral flexion, because in cervical rotation, the articular process of one side glides upward and forward, and that of the opposite side glides downward and backward. This is due to the upward and medial inclinations of the superior articular surfaces, and the slight medial inclination prevents rotation in its strict sense. There is a slight lateral

bending of the cervical spinal column as the head is rotated through its arc.

In the thoracic region, rotation is relatively free because of the position and the direction of the articular processes. This movement is greater in the upper thoracic than the lower thoracic region. Dynamically, the thoracic region may be considered as a long cylinder whose central point of rotation is located in front of the vertebral bodies.

In the lumbar region, rotation is very slight due to the interlocking of the articular surfaces. Such rotation as is present is permitted by the spaces between these surfaces, and as soon as this slack is taken up, rotation ceases.

Movements permitted at the sacrococcygeal and intercoccygeal joints are negligible, and are limited to a slight anterior and posterior direction. During childbirth, the coccyx is pushed backward, and such movement may also occur during defecation. Antagonistic to this backward push is the forward pull of the Levator ani and the coccygeus muscles of the pelvic floor. Since these joints usually ossify by middle life, such movement as is present is confined to the earlier years of life.

MUSCLE DYNAMICS OF THE VERTEBRAL COLUMN

The thoracic portion of the spinal column forms a convex backward curve so that the weight of the upper half of the trunk and the upper limbs is supported by a part of this curve. The center of gravity of the trunk lies at the level of the ninth thoracic vertebra, but is several inches in front of the vertebral body. The center of gravity of the entire body standing in the erect position is opposite the third sacral vertebra at about the level of the lower borders of the sacroiliac joints.

The spinal column is a dynamic indicator of myogenic equilibrium, the result of nervous control on the bilateral muscles pulling against the resistance of gravity. In order to function normally and to provide the proper symmetry of both halves of the trunk, it is necessary that the involved muscles and the spinal centers of gravity be normal.

Proper spinal form is dependent upon the pull and counterpull of muscles directly affecting the spinal column. Obviously the majority of these muscles are directly attached to the

column, but there are others such as the rectus abdominis and intercostals which also affect spinal position.

On a physiological basis, it is possible to classify into four groups the musculature that influences spinal position. These are:

1. **The superficial parallel hamstring muscles:** Sacrospinalis, Intercostals, and Rectus abdominis muscles.
2. **The deep parallel hamstring muscles:** Intertransverse muscles.
3. **The superficial transverse torsion muscles:** Trapezius, Lattissimus dorsi, Serratus anterior, and Pectoralis major muscles.
4. **The deep torsion muscles:** Semispinalis, Multifidus, and Rotator muscles.

In order to properly evaluate the parts played by these four muscle groups in maintaining normal spinal position, it is necessary to consider the body as a four-sided figure similar to an oblong. The spinal region represents one side, the anterior median line of the body another side, and the third and fourth sides correspond to the two lateral sides of the trunk. If all four sides function properly and harmoniously, there will be normalcy of spinal position, but if one part of the four groups of muscles becomes abnormal due to nerve interference, the result will be distortion and disharmony of the spinal movements.

For example: if the right Trapezius muscle is weakened or paralyzed, the unopposed left Trapezius muscle will draw the spinal column toward the left side. Generally, the involved vertebrae will be rotated toward the side of the curvature. If the right external Intercostal muscles, or the right Rectus abdominis muscles are paralyzed, those on the left side will act as a hamstring and produce a lateral bending of the spinal column with the convexity toward the right side.

Considering the deep parallel hamstring muscles as the intertransversarii, if the right intertransversarii are paralyzed, there will be produced a right rotary curvature due to the tension of the left intertransversarii muscles.

Weakness or paralysis of the deep torsion muscles of one side will produce a definite rotation of the vertebral bodies. For

example, if the left side of this group is weak, the normal tonicity of the right side will rotate the bodies toward the left.

MOVEMENTS OF THE VERTEBRAL COLUMN

The true muscles of the back are those that produce flexion extension, lateral flexion, and rotation. However, it is not possible to consider one muscle, or a single muscle group, as having but one designated action because the movements of the vertebral column represent the sum total of many muscles acting coordinately. For example, the entire Sacrospinalis muscle, acting bilaterally, will extend the spinal column, but if only one side contracts, the action is one of lateral flexion. The Semispinalis and Multifidus muscles also aid in extension, but acting on one side they assist in lateral flexion and also tend to rotate the vertebral bodies toward the opposite side. The Rotatores are so named because of their action in rotating the spinal segments.

The primary function of the true back muscle is to bring about extension of the vertebral column in maintaining the erect posture. The other spinal movements of flexion, lateral flexion, and rotation, are dependent upon the back muscles for action of the immediate vertebrae involved; but flexion, lateral flexion, and rotation of the spinal column as a whole are also helped greatly by muscles which have little or no attachment to the axial skeleton. Thus, the Rectus abdominis, attaching to the thoracic cage and the pubis, acts to flex the lumbar spinal column; the Sternocleidomastoideus helps in flexion, lateral flexion, and rotation of the cervical region and the skull; and the muscles of the anterior and lateral abdominal walls assist in flexion and rotation of the thoracic and lumbar spinal regions. Further consideration of these spinal movements is discussed in the section dealing with the muscle dynamics of the vertebral column.

PRINCIPAL MUSCLES OF SPINAL MOVEMENTS

Flexion is produced mainly by the Longus capitis, Longus colli, the Scaleni, the Sternocleidomastoideus, the Psoas major, and the abdominal muscles.

Extension muscles include all deep spinal muscles, the Multifidus, the Splenius capitis, the Splenius colli, and the Semispinalis muscles.

The muscles of **Lateral flexion** include the deep spinal muscles, the Splenius capitis, the Splenius colli, the Scaleni, the Psoas major, and the Quadratus Lumborum, when the muscles are contracting unilaterally.

Rotation is accomplished by the action of the muscles of one side only. The muscles of spinal rotation include the Sternocleidomastoideus, the Longus capitis, the Scaleni, the Multifidus, the Rotatores, the Semispinalis capitis and the Anteriolateral abdominal muscles.

SUMMARY OF ACTION OF SPINAL MUSCLES

1. Muscles Acting on the Head—at Atlanto-Axial and Atlanto-Occipital Joints

A. Extension:
Trapezius
Semispinalis capitis
Rectus capitis posterior major
Rectus capitis posterior minor
Obliquus capitis superior
Splenius capitis
Longissimus capitis
Sternocleidomastoideus

Flexion:
Longus capitis
Rectus capitis anticus

B. Head Rotation to Right:
Left trapezius
Left sternocleidomastoideus
Right splenius capitis
Right longissimus capitis
Right obliquus capitis inferior
Right longus capitis
Right rectus capitis posterior major

Head Rotation to Left:
Right trapezius
Right sternocleidomastoideus
Left splenius capitis
Left longissimus capitis
Left obliquus capitis inferior
Left longus capitis
Left rectus capitis posterior major

C. Lateral Bending to Right:
Right sternocleidomastoideus
Right splenius capitis
Right longissimus capitis
Right semispinalis capitis
Right rectus capitis lateralis

Lateral Bending to Left:
Left sternocleidomastoideus
Left splenius capitis
Left longissimus capitis
Left semispinalis capitis
Left rectus capitis lateralis

2. Muscles Acting on Cervical Region

A. Extension:
Semispinalis capitis
Semispinalis cervicis
Splenius capitis
Splenius cervicis
Spinalis cervicis
Interspinales
Longissimus cervicis
Iliocostalis cervicis
Multifidus

Flexion:
Sternocleidomastoideus
Longus colli
Scaleni group
Longus capitis

B. Rotation to the Right:	Rotation to the Left:
Right splenius capitis	Left splenius capitis
Right splenius cervicis	Left splenius cervicis
Right longissimus cervicis	Left longissimus cervicis
Right iliocostalis cervicis	Left iliocostalis cervicis
Left sternocleidomastoideus	Right sternocleidomastoideus
Left semispinalis cervicis	Right semispinalis cervicis
Left rotatores	Right rotatores
Left trapezius	Right trapezius
Left scaleni group	Right scaleni group

C. Lateral Bending to Right:	Lateral Bending to Left:
Right sternocleidomastoideus	Left sternocleidomastoideus
Right scaleni group	Left scaleni group
Right splenius capitis	Left splenius capitis
Right splenius cervicis	Left splenius cervicis
Right longissimus capitis	Left longissimus capitis
Right longissimus cervicis	Left longissimus cervicis
Right semispinalis cervicis	Left semispinalis cervicis
Right intertransversarii	Left intertransversarii
Right levator scapulae	Left levator scapulae
Right iliocostalis cervicis	Left iliocostalis cervicis

3. Muscles Acting on Thoracic Region

A. Extension and Right Lateral Bending:	Extension and Left Lateral Bending:
Right iliocostalis	Left iliocostalis
Right multifidus	Left multifidus
Right spinalis dorsi	Left spinalis dorsi
Right rotatores	Left rotatores
Right semispinalis dorsi	Left spinalis dorsi
Right levatores costarum	Left levatores costarum
Right longissimus dorsi	Left longissimus dorsi

B. Right Rotation:	Left Rotation:
Right iliocostalis	Left iliocostalis
Right internal abdominal oblique	Left internal abdominal oblique
Left semispinalis dorsi	Right semispinalis dorsi
Left multifidus	Right multifidus
Left rotatores	Right rotatores

4. Muscles Acting on Lumbar Region

A. Extension:	Flexion:
Interspinales	Psoas major
Multifidus	Psoas minor
Intertransversarii	Rectus abdominus
Sacrospinalis	
Quadratus lumborum	

B. Lateral Bending to Right:	Lateral Bending to Left:
Right quadratus lumborum	Left quadratus lumborum
Right intertransversarii	Left intertransversarii
Right psoas magnus	Left psoas magnus
Right exterior abdominal oblique	Left exterior abdominal oblique
Right interior abdominal oblique	Left interior abdominal oblique

Chapter 6

JOINTS AND LIGAMENTS OF THE VERTEBRAL COLUMN

A joint is the union between two or more bones or cartilages. The various bones, and some cartilages, of which the skeleton consists are connected at different parts of their surfaces and such connections are called joints or articulations. The study of these joints is dealt with extensively by any good anatomy text; in fact, such a study comprises a section of the study of human anatomy. However, the approach to Chiropractic orthopedy requires that this study, or Arthrology, be confined to those joints found in the spinal column. Fundamentally, joints are classified according to the amount of movement of which they are capable, and three main types are considered:

1. Immovable joints or synarthroses.

2. Slightly movable joints or amphiarthroses.

3. Freely movable joints or diarthroses.

Each of these main types has several varieties which are described in detail with the appropriate spinal joints.

A ligament is composed of white fibrous connective tissue that helps to hold the bone together at the joints. It is a strong flexible band, or capsule, made up of bundles of collagenous fibers either running parallel to each other or slightly interweaving. The typical spinal ligament is white, shiny and silvery in appearance, having great tensile strength the better to hold the articulating surfaces of joints together—even under great applied force. The study of the ligaments of the body constitutes a branch of anatomy known as Syndesmology. Because of the importance of ligaments to the formation of a joint, it is customary to include the features of both Syndesmology and Arthrology in

considering a specific joint. This plan will be followed in the study of the individual vertebral articulations.

JOINTS OF THE VERTEBRAL COLUMN

With certain exceptions, the joints of the vertebral column follow a set pattern and are classified into two main types. (1) A series of slightly movable joints or amphiarthroses between the vertebral bodies, and (2) a series of freely movable joints or diarthroses between the vertebral arches. This group is composed of the articular processes and includes the connections by ligaments of the laminae, spinous processes and transverse processes.

1. UNIONS OF THE BODIES OF MOVABLE VERTEBRAE

Type of joint—Amphiarthrodial, Symphysis. The classification given to the joints between the bodies is amphiarthrodial symphysis—amphiarthrodial because of the limited motion, and symphysis due to the presence of an intervertebral disc. The articulations of the vertebral bodies are excellent examples of secondary cartilaginous joints as the cartilaginous discs separate the bones as well as uniting them. The articular surfaces of the bodies are covered with hyaline cartilage and are united by an intervening disc of fibro-cartilage enclosed within a ring of strong fibrous tissue which is continuous with the periosteum of the vertebral bodies. The limited motion is possible because of the twisting or torsion of the disc at its various points when under pull or pressure. These joints persist throughout life between the bodies of movable vertebrae, but in the sacral and coccygeal regions are replaced at adulthood by immovable joints or synarthroses.

Ligaments—anterior longitudinal, posterior longitudinal, intervertebral fibro-cartilagenous.

The Anterior Longitudinal or Anterior Common Ligament—is wide and thick. It extends from the anterior surface of the body of axis where it is continuous with the anterior atlanto-axial ligament, down as far as the first segment of the sacrum. It is reinforced in the abdomen by the crura of the diaphragm, and in the upper thoracic region by the lower parts of the longus colli muscles. In the cervical region, it lies between these muscles as a thick, narrow band. The ligament is made up of dense

longitudinal fibers which fuse strongly to the intervertebral discs and to the margins of the vertebral bodies. It consists of several layers of fibers, some superficial, some middle, and some deep. The superficial layers extend between the bodies of four vertebrae, the middle layers run between two or three vertebrae, and the deep layer connects one vertebral body to the next. The anterior longitudinal ligament is narrowest at its axis beginning, but gradually becomes wider as it descends reaching a width of about one and two-thirds inches in the lumbar region. It is thickest in the thoracic region, and thicker in the lumbar than the cervical. At the sides of the vertebral bodies it presents a series of short fibers which run from one vertebral body to the next. Between the lateral or short vertebral ligaments and the lateral margins of the anterior ligament proper is a series of small oval openings for the passage of blood vessels.

The Posterior Longitudinal or Posterior Common Ligament—is not as wide as the anterior spinal ligament, but it is denser and more compact. It presents a dentate or serrated appearance due to being alternately wide at the intervertebral disc and narrow where it runs over the center of the bodies.

The posterior longitudinal ligament extends along the posterior surfaces of the bodies of the vertebrae from the body of the axis, where it is continuous with the membrana tectoria, to the sacrum. It, like the anterior ligament, is made up of superficial layers of smooth, white, shining longitudinal layers extending between three or four vertebrae, and short, deep layers between adjacent vertebrae.

Intervertebral Fibro-Cartilages or Intervertebral Discs. The intervertebral discs are located between the bodies of adjacent vertebrae from the axis to the sacrum, and are the principal means of connection between these structures. They are twenty-three in number, and are attached firmly to the articular cartilage that covers the superior and inferior surfaces of the bodies. They form about one-quarter of the length of the spine; varying in size, shape and thickness in different spinal regions. They are thickest in the lumbar region. For the most part, they correspond in size and shape with the surfaces of the bodies between which they are placed except in the cervical region where they do not reach the postero-lateral edges of the bodies. The disc between the axis and third cervical is small and relatively weak, although the disc between the fifth and sixth cervical vertebrae

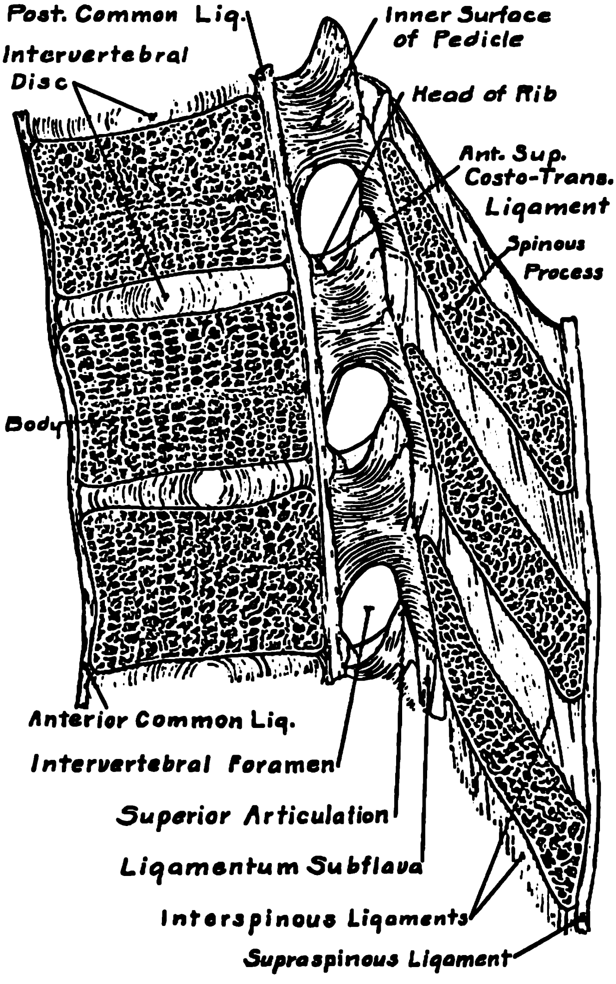


Fig. 54. Median section through three thoracic vertebrae showing spinal ligaments.

is even smaller. The discs vary in thickness within themselves as in the cervical and lumbar regions where each disc is more thick anteriorly than posteriorly and thus helps form the anterior convex curves of these spinal regions. In the thoracic region the discs seem to be virtually the same thickness both at the anterior and at the posterior.

By their circumferences, the discs are intimately connected in front to the anterior longitudinal ligament and behind to the posterior longitudinal ligament. In the thoracic region they are joined laterally by interarticular ligaments to the heads of those ribs which articulate with two adjacent vertebrae.

2. ARTICULATIONS OF THE VERTEBRAL ARCHES

These articulations are united by the capsules of synovial joints between the articular processes, and by the following ligaments—intertransverse, interspinous, supraspinous, and ligamentum flava.

Articulations Between the Articular Processes

Type of joint—Diarthrodial, Arthrodial

These joints are so classified because of the freedom of motion (diarthrodial) and the gliding, rolling type of motion (arthrodial). In fact, the joints between the articular processes of adjacent vertebrae are outstanding examples of the gliding movement of an arthrodial joint.

Articular Capsules or Capsular Ligaments—are thin and loose to allow gliding of the joint surfaces. They are longer and looser in the cervical than in the thoracic and lumbar regions. There is a capsular ligament for each pair of articular processes of adjacent vertebrae, and it is attached to the margins of the processes. The typical capsular ligament of an intervertebral articulation is a short, wide tube attached by its ends to the post-zygapophysis of one vertebra and the pre-zygapophysis of the vertebra next below. It is made of strong fibrous tissue, and is frequently thickened and strengthened by fusion with adjacent ligaments or tendons or deep fascia.

Each capsular ligament is lined by **Synovial Membrane** which is also reflected onto the outer surface of the articular

process up to the margins of the articular cartilage that covers the articular surface of each process.

The lining of Synovial Membrane is smooth, velvety, and very vascular. It is composed of very fine connective tissue supporting on its inner surface many small elevations called Synovial villi concerned with the secretion of an oily fluid known as synovial fluid or synovia. The synovia lubricates the joint structures, provides nourishment for the articular cartilage, and is a source of phagocytic cells available for routine and emergency phagocytosis.

To properly consider the anatomy of an articular capsule, it should be considered as being made up of two distinct layers—an outer Capsular Ligament and an inner Synovial Membrane.

Articulations of the Spinous Processes

Type of joint—Amphiarthrodial, Syndesmosis

The spinous processes of the vertebrae are each some distance apart and so are united by a series of ligaments which allow slight movement (amphiarthroses) by twisting and very slight stretching. Because of the distances between spinouses the length of intervening ligaments properly puts them in the category of an interosseous ligament, hence the classification syndesmosis.

Three ligaments connect the spinous processes and they are: the supraspinous, the ligamentum nuchae, and the interspinous.

The Supraspinous Ligament or Supraspinal Ligament—forms a long, continuous, fibrous cord which connects together the tips of the spinous processes from the seventh cervical down to the sacrum. It has a superficial and deep layer of fibers. The superficial fibers are longer as they pass between three or four different spinouses, whereas the deep fibers run only between two adjacent spinous processes. The ligament is thick and broad in the lumbar region where its fibers interweave with the lumbodorsal fascia.

Above the level of the seventh cervical vertebra, the supraspinous ligament is continued upward as the ligamentum nuchae.

The Ligamentum Nuchae—extends upward from the tip of the seventh cervical spinous process to the external occipital

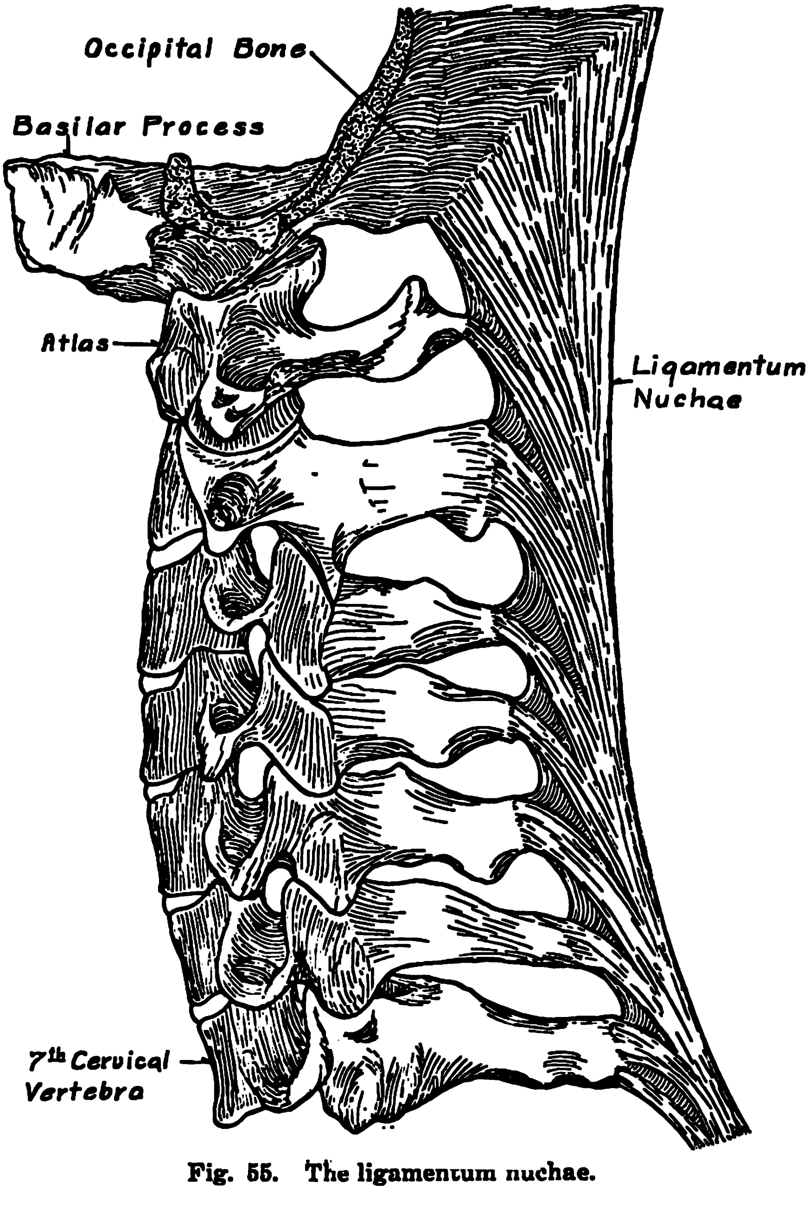


Fig. 55. The ligamentum nuchae.

protuberance and the crest of the occipital bone. It is a thin triangular sheet with its base upward and apex at the seventh cervical. The ligamentum nuchae is made up mostly of white fibrous tissue with some yellow elastic fibers.

Its anterior border is attached to the tips of all the cervical spinouses as well as the posterior tubercle of atlas and the occipital crest. Its posterior border is a free edge stretching from the seventh cervical spinous to the external occipital protuberance and gives origin to parts of the trapezius and splenius muscles of the neck.

In some of the lower animals, such as the horse and cow, it is made up almost entirely of elastic tissue to help in supporting the head and neck. However, in man the elastic element is rudimentary probably due to the upright position of the body.

The Interspinous Ligaments or Interspinal Ligaments are thin membranous ligaments attached to adjacent spinous processes and run obliquely downward from the base of a spinous to the tip of the one next below. Each is joined with the supraspinous ligament behind, and in front it fuses with the ligamentum flava.

The interspinous ligaments are long and narrow in the thoracic region; broad and thick in the lumbar region; and only slightly developed in the cervical region where they are mostly replaced by the strong interspinal muscles.

Articulations of the Laminae

Type of joint—Amphiarthrodial, Syndesmosis

Slight movement is possible between the laminae of adjacent vertebrae, and such motion is chiefly a drawing forward or backward in flexion or extension of the spinal column. Because the laminae are connected by ligaments running between them, the joints are considered as being syndesmoses. These ligaments are known collectively as the Ligamenta Flava; powerful, elastic ligaments which assist the vertebral column to resume its normal shape after spinal flexion.

The Ligamenta Flava or Ligamenta Subflava—are a pair of thin, strong, elastic sheets that connect the laminae of two adjacent vertebrae. Because they are composed of yellow elastic tissues, they are frequently referred to as the Yellow Ligaments.

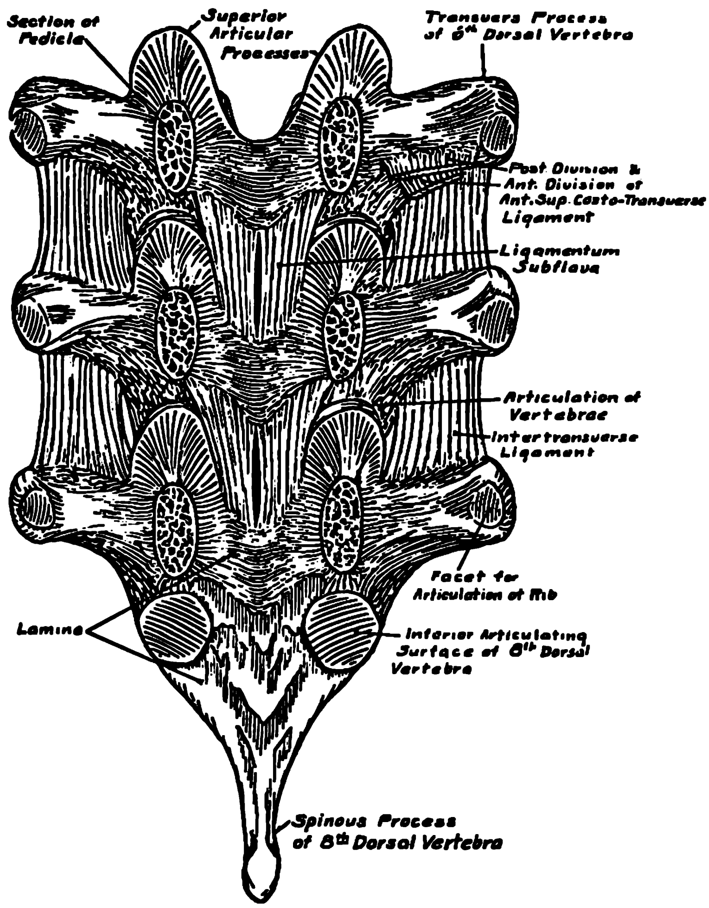


Fig. 56. The anterior surface of the laminae and ligamenta subflava as seen from inside of thoracic neural canal. The pedicles have been sectioned and the bodies removed.

They are found running between the laminae of adjacent vertebrae from the axis to the first sacral segment.

The ligamenta flava are best seen from the interior of the vertebral canal, being partly covered on their outer surfaces by the overlapping of the laminae. Laterally, each blends with the capsular ligament of its level; medially, they are separated by a narrow interval of epidural fat.

Superiorly, each attaches to the inner surfaces and lower border of the laminae; except in the thoracic region where the attachment is to the inner surface only. Inferiorly, each attaches to the outer surface and upper border of the lamina next below. In the cervical region the ligaments are thin, but broad and long; they are thicker and narrow in the thoracic region; and are thickest and strongest in the lumbar region.

Articulations of the Transverse Processes

Type of Joint—Amphiarthrodial, Syndesmosis.

The apices of the transverse processes of adjacent vertebrae are connected by a series of flat, thin ligamentus bands known as the intertransverse ligaments.

The intertransverse ligaments—are very weak and poorly developed. In the cervical region they are for the most part replaced by the intertransverse muscles. In the thoracic region they are small round cords attached to the deep muscles of the spinal column and in the lumbar region the intertransverse ligaments are flat membranous bands.

NINE COMMON LIGAMENTS

It is common practice to speak of the nine ligaments of the vertebral articulations as the "nine common ligaments to the spinal column." These may be divided into three main groups:

A. Ligaments attached to the vertebral bodies:
   1. Intervertebral discs
   2. Anterior longitudinal ligament
   3. Posterior longitudinal ligament

B. Ligaments attached to the spinous processes:
   1. Supra-spinous ligament
   2. Inter-spinous ligament
   3. Ligamentum nuchae

C. **Ligaments attached to laminae, articular processes, and transverse processes:**
   1. **Ligamenta flava**
   2. **Capsular ligaments**
   3. **Intertransverse ligaments**

ARTICULATION OF ATLAS WITH AXIS

Atlanto-Epistrophic Articulation

The joints between the atlas and axis are four in number: two central atlanto-epistrophic or atlanto-dental, and two lateral atlanto-epistrophic.

1. **Central Atlanto-Epistrophic** joints are freely movable and form a pivot joint; hence they are classified as **Diarthrodial Trochoides.** The two central joints include an anterior articulation between the odontoid process and the back of the anterior ring of atlas and a posterior articulation between the odontoid process and the transverse ligament of the atlas.

The articular surfaces of the odontoid process and the fovea dentalis of atlas are covered with articular cartilage, between which is a sac-like joint capsule containing synovial fluid.

Between the back of the odontoid process and the anterior surface of the transverse ligament is the posterior division of the central joints, and this also has a synovial cavity between the articulating surfaces.

2. **Lateral Atlanto-Epistrophic** joints are classified as **Diarthrodial Arthrodial** because of their free gliding movement. These two lateral joints are formed between the superior articular surface of axis and the lower surface of the lateral mass of atlas. The articulating surfaces of each joint have the usual articular cartilage and are separated by a synovial membrane which is the lining of the capsular ligament.

The ligaments of the atlas-axis articulation are:

Two Articular Capsules

The Anterior Atlanto-Axial

The Posterior Atlanto-Axial

The Transverse

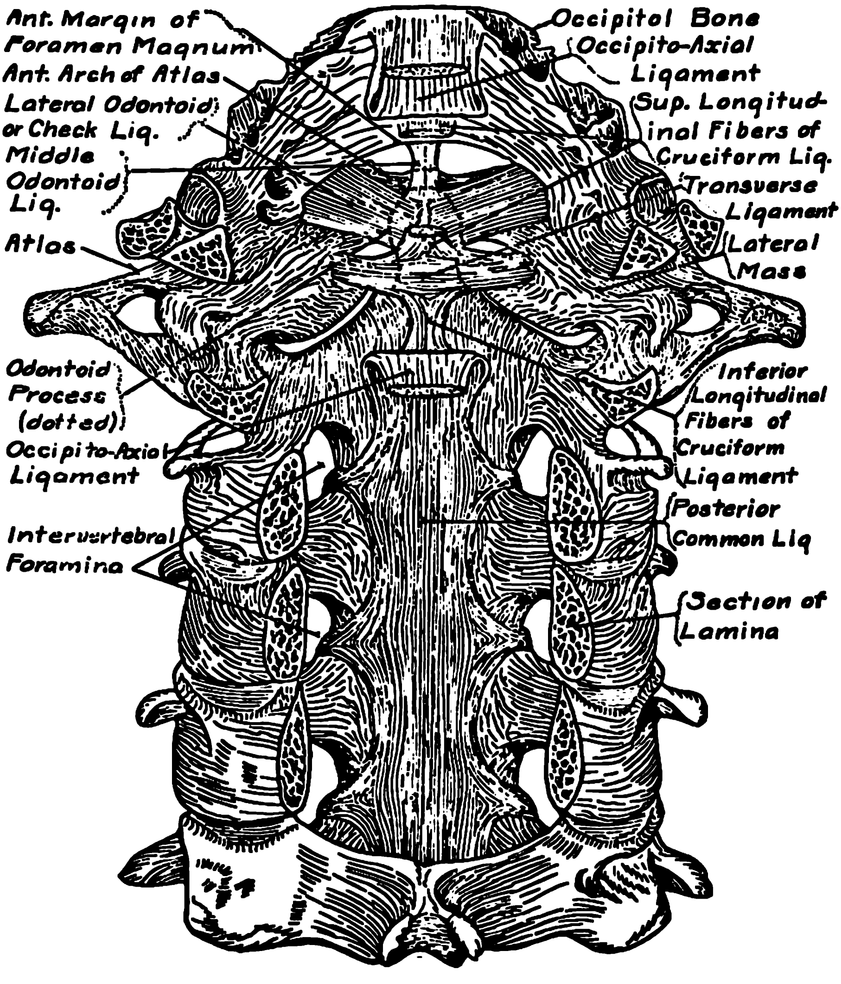


Fig. 57. Cervical region with portion of vertebral arches removed showing ligaments and posterior surfaces of vertebral bodies.

The Articular Capsules or Capsular Ligaments are thin and loose, attaching near the margins of the articulating surfaces of atlas lateral masses and the axis superior articular surfaces. Each ligament is strongest in its postero-medial area because of the presence of an Accessory Ligament which is attached below near the base of the odontoid and runs upward to the atlas lateral mass near the transverse ligament.

Anterior Atlanto-Axial Ligament is a narrow but strong membrane attaching above to the lower border of the atlas anterior ring and below to the transverse ridge on the front surface of the axis body. It is greatly strengthened in the median line by the addition of fibers continuing upward from the anterior longitudinal ligament of the spinal column. These central fibers attach the body of the axis to the anterior tubercle of atlas.

Posterior Atlanto-axial Ligament is a broad, thin, loose ligament joining the lower border of the posterior arch of atlas and the upper edges of the axis laminae. The ligament extends between the posterior root of the transverse process of one side to that of the opposite side, thus enclosing most of the space between the neural arches of the two vertebrae. It has a layer of elastic tissue on its anterior surface which layer corresponds to the first pair of ligamenta flava uniting the axis laminae to the atlas posterior arch. It is stronger and thicker in the median line due to the presence of a band of fibers from the ligamentum nuchae which unites the spinous process of axis to the posterior tubercle of atlas. On either side the posterior atlanto-axial ligament is pierced by the second cervical nerve.

Transverse Ligament of the atlas is a strong, thick, curved band that stretches across the back of the odontoid process and holds it in place against the anterior arch of the atlas. It is concave in front, convex behind, and is thick and broad at its center with gradually tapering lateral portions each of which attaches to a small tubercle on the medial surface of the lateral mass of atlas.

ARTICULATION OF THE ATLAS WITH THE OCCIPITAL BONE

Atlanto-Occipital Joint

This articulation consists of a pair of similar joints located on either side of the median line. The joint of each side is made

up of the cup-shaped superior articular facet of the lateral mass of atlas and the condyle of the occipital bone. The atlanto-occipital articulation is considered freely movable, has a gliding motion between the articular surfaces; condyles enter into its formation, and there is a slight hinge-like motion possible; accordingly it is classified as a Diarthrodial-Arthrodial, Condyloid and Ginglymus Joint.

The ligaments connecting the bones are:

Two Articular Capsules

The Anterior Atlanto-Occipital Membrane

The Posterior Atlanto-Occipital Membrane

Two Lateral Atlanto-Occipital Ligaments

The Articular Capsules—surround the condyles of the occipital bone and connect them with the lateral masses of the atlas. Each capsule is loosely attached, and is a thin membrane except on its lateral border. It fuses firmly with the anterior aspect of the lateral mass with some of its fibers descending as far as the base of the transverse processes.

Each of the articular capsules is lined by a synovial membrane and frequently the membranes are in direct communication with the synovial joint between the posterior surface of the odontoid process and the transverse ligament of the atlas.

The joint is opposite the mastoid process, and shows the following relations:

Anteriorly—the rectus capitis anterior muscle

Posteriorly—the rectus capitis posterior major muscle

Laterally—the hypoglossal nerve and internal jugular vein

Medially—the medullar oblongata and the apex of the odontoid process of axis.

The first cervical nerve crosses the posterior arch of the atlas behind the joint and directly above the nerve the vertebral artery winds around the back of the lateral mass—thus both nerve and artery emit or enter posteriorly to the articular capsules.

The Anterior Atlanto-Occipital Membrane—connects the anterior arch of the atlas with the anterior margin of the foramen magnum. It is nearly an inch wide and fuses laterally with the fibers of the articular capsules. A thickened band of fibers in the middle ascends vertically from the anterior tubercle of the atlas to the basilar part of the occipital bone and represents an upward continuation of both the anterior longitudinal ligament, and the anterior atlanto-epistrophic ligament. In front of the anterior atlanto-occipital membrane lie the recti capitis anteriores muscles, and behind it lie the apical and alar ligaments.

The Posterior-Atlanto-Occipital Membrane—is much wider than the anterior, but it is also thin. Above, it is connected to the posterior margin of the foramen magnum from condyle to condyle; below, to the upper border of the posterior arch of the atlas. At each side it fuses with the articular capsule and bridges over the groove for the vertebral artery to convert the groove into a foramen for the passage of the vertebral artery and the first cervical nerve. Sometimes this portion of the ligament is ossified to complete a bony foramen on the upper surface of the atlas posterior arch.

Internally, the membrane is adherent to the uppermost part of the spinal dura mater; and externally, it is covered by the Recti capitis posteriores minores and Obliqui capitis superiores.

Two Lateral Atlanto-Occipital Ligaments—or **Anterior Oblique Ligaments** are accessory fibrous bands that strengthen the articular capsules laterally. Each is a thick band of fibers running from the base of a transverse process of atlas upward and medialward to its corresponding jugular process of the occipital bone.

LIGAMENTS CONNECTING THE OCCIPITAL BONE AND THE AXIS

The occipital bone and the axis vertebra do not unite to form an articulation, but instead are united by ligaments which, for the most part, occupy positions within the anterior

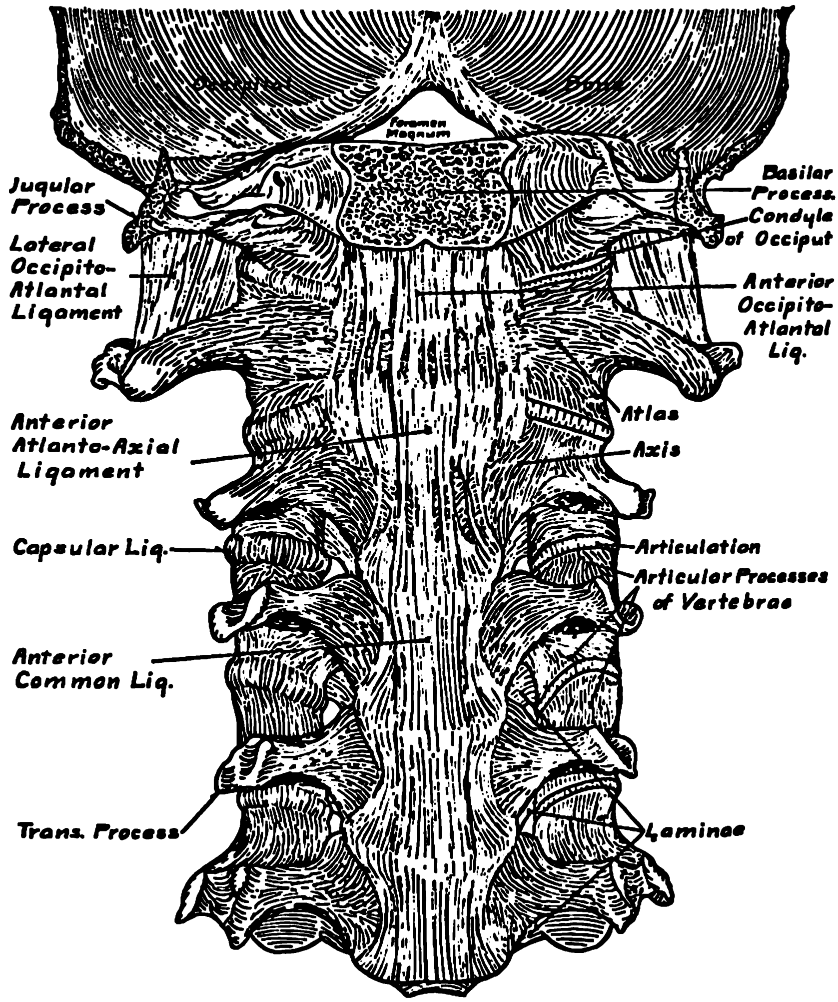


Fig. 58. Anterior view of the cervical region showing the ligaments.

portion of the vertebral canal and foramen magnum at these levels.

The ligaments uniting these bones are:

Membrana Tectoria

Two Alar

Apical Ligament of the Odontoid

Cruciate Ligament

Ligamentum Nuchae

The Membrana Tectoria, or **Occipito-Axial Ligament** is a thin, wide ligament continuous inferiorily with the posterior longitudinal ligament. It is situated within the vertebral canal. Attaching below to the back of the body of axis and widening as it ascends it fuses with the cranial dura mater in the basilar groove of the occipital bone. Its anterior surface is in contact with the transverse ligament of the atlas and the odontoid process and its ligaments, while its posterior surface is adherent to the upper part of the spinal dura mater. Laterally, the tectorial membrane fuses with the articular capsules of the atlanto-axial articulation.

Two Alar Ligaments—or Check Ligaments—or Odontoid Ligaments—are a pair of strong rounded cords that pass from the sides of the apex of the odontoid process upward and laterally to insert into the medial sides of the occipital condyles. As each ligament runs obliquely upward it gives off strengthening fibers at the condyles to the capsule of the atlanto-occipital articular capsule.

Between the rough inverted triangle formed by the two alar ligaments is a small weak ligament—**the Apical Ligament of the Odontoid Process, or Suspensory Ligament,** which extends from the apex of the odontoid process upward to the middle of the anterior margin of the foramen magnum. It contains the remains of the notochord at this level, and is considered a rudimentary intervertebral fibrocartilage. It is in front of the upper band of the cruciate ligament and behind the anterior atlanto-occipital membrane with which it is strongly fused.

Cruciate Ligament—is composed of the transverse ligament of the atlas and two longitudinal bands known as the Cranial crus

and the Caudal crus. The transverse ligament forms the horizontal arm of the cross, while the vertical portion is comprised of cranial and caudal sections. The cranial crus is a strong band of fibers stretching upward from the transverse ligament to the basilar part of the occiput; the caudal crus runs downward from the transverse ligament to the back of the body of axis.

The Ligamentum Nuchae—is considered a ligament connecting the axis and the occipital bone as it connects the axis spinous process with the external occipital crest and protuberance.

ARTICULATION BETWEEN THE FIFTH LUMBAR AND THE SACRUM

The joints and ligaments between the fifth lumbar vertebra and the sacrum are similar to those which join the movable vertebra of the spinal column with each other. The articulations between these two vertebral bodies are: a typical Amphiarthrodial Symphysis because of the limited motion and intervening intervertebral disc, and between the articular processes a pair of Diarthrodial Arthroses.

The ligaments include: 1. The continuation downward of the anterior and posterior longitudinal ligaments. 2. The intervertebral disc. 3. Ligamenta flava connecting the laminae of the fifth lumbar with those of the first sacral vertebra. 4. Capsular ligaments surrounding the articular processes. 5. Interspinal and supraspinal ligaments.

In addition to these ligaments, the union of the two bones shows additional ligaments which attach the fifth lumbar not only to the sacrum, but indirectly to the pelvis as well. There are two pairs of these ligaments: Iliolumbar and Lumbosacral.

The Iliolumbar Ligament—is a dense, strong, triangular ligament. It arises above from the lower and anterior surface of the fifth lumbar transverse, and fans out as it passes lateralward to be attached to the sacrum and the ilium. Its lower fibers run obliquely downward to attach to the base of the sacrum where they blend with the anterior sacro-iliac ligament; its upper fibers pass to the crest of the ilium in front of the sacro-

iliac joint, and fuse with the lumbodorsal fascia. The iliolumbar ligament is covered in front by the Psoas major muscle.

The Lumbosacral Ligament—is considered as a part of the iliolumbar ligament as it cannot be separated from the latter. It is a triangular band of fibers attached above to the transverse process and body of the fifth lumbar vertebra, and below to the base and pelvic surface of the sacrum. Its medial border forms the lateral margin of the intervertebral foramen transmitting the fifth lumbar nerve. This ligament corresponds to the usual intertransverse ligament of the spinal column. The fibers of both the iliolumbar and lumbosacral ligaments are so closely intertwined that for all practical purposes the lumbosacral may be considered as a division of the iliolumbar ligament, and is considered separately only because of its slightly different course to that of the main part of the iliolumbar.

ARTICULATION BETWEEN THE SACRUM AND THE COCCYX

The Sacro Coccygeal Symphysis is an **Amphiarthrodial Symphysis** formed between the apex of the sacrum and the base of the coccyx. It compares with the joints between the bodies of the vertebrae, and is bound together by the following ligaments: intervertebral fibrocartilage, anterior sacrococcygeal, superficial posterior sacrococcygeal, deep posterior sacrococcygeal, lateral sacrococcygeal, and interarticular.

The Intervertebral Fibro Cartilage—is located between the two articular surfaces of the bones. It is somewhat thinner than the usual intervertebral disc, and is oval in shape, being about three-fourths of an inch wide and a half inch from front to back. The disc is closely connected with the surrounding ligaments.

Anterior Sacrococcygeal Ligament—is a thin band of fibers representing the lower extremity of the anterior longitudinal ligament. It connects the body of the fifth sacral segment with the body of the first coccygeal segment.

Superficial Posterior Sacrococcygeal—runs a longer course than does the deep posterior sacrococcygeal ligament. It arises from the margins of the sacral hiatus and descends to the posterior surface of the coccyx. It forms a roof over the lower end of

the vertebral canal where the laminae are deficient at the sacral hiatus.

The Deep Posterior Sacrococcygeal Ligament—is a direct continuation of the posterior longitudinal ligament and connects the fifth sacral and first coccygeal segments. It finally blends with the filum terminale and the superficial posterior sacrococcygeal ligament.

Lateral Sacrococcygeal Ligaments—are paired, and connect the lower lateral angles of the sacrum with the transverse processes of the first coccygeal segment. Each completes the foramen for the fifth sacral nerve on its corresponding side.

Interarticular or Intercornual Ligaments—are thin ligamentous bands which unite the cornua of the sacrum and the coccyx.

INTERCOCCYGEAL JOINTS

During every adult life, the joints between the segments of the coccyx are classified as Amphiarthrodial-Symphyses because of the intervening fibrocartilage discs; but in later life, the coccyx is a single bone of fused segments and may be properly considered as Synarthroses with a sub-type of Synostoses.

The four coccygeal vertebrae are held together by downward continuations of the anterior and posterior sacrococcygeal ligaments and thin, fibrocartilage intervertebral discs. Laterally, the joints are strengthened by the sacrosciatic ligaments which are attached along the lateral borders of the coccyx.

In the adult male, the segments tend to become ossified together at about the ages of 18 to 25, but this fusion is delayed until a later date in the female. It is also common for the joint between the sacrum and coccyx to become ossified at about middle age. Again, this occurs at a later period in the female than the male, probably because of the increased flexibility of this joint during pregnancy and childbirth.

JOINTS AND LIGAMENTS OF THE PELVIS

The joints and connecting ligaments of the pelvis may be divided into four groups:

1. Those uniting the sacrum and coccyx.

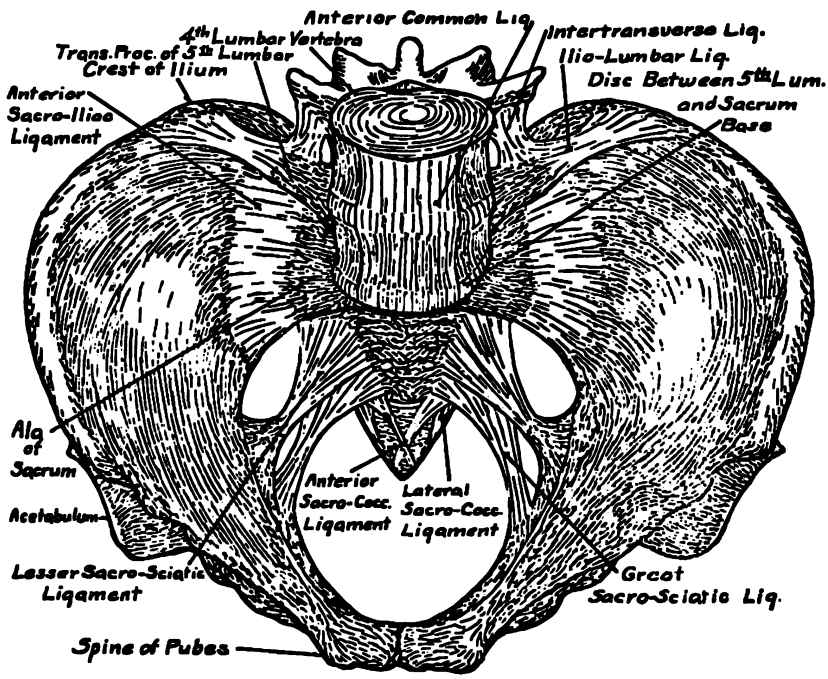


Fig. 59. Anterior view of the pelvis and lower lumbars showing the principal ligaments.

2. Those connecting the two pubic bones.

3. Those between the sacrum and the ilium.

4. Those joining the sacrum and the ischium.

The sacro-coccygeal joint and its ligaments are described as a part of the vertebral column, and the inter-pubic articulation is best considered in the general study of arthrology and syndesmology, as it is not directly concerned with the vertebral articulations. However, the connections of the sacrum with the ilium, and with the ischium, are a part of the spinal column from the standpoint of Chiropractic technic as well as that of anatomy. Indeed, the sacroiliac region has long been one of the outstanding areas of consideration by the science of Chiropractic because of its involvement in lower back disorders.

THE SACROILIAC ARTICULATION

Amphiarthrodial-Syndesmosis

The proper classification of this important articulation between the auricular surfaces of the sacrum and the ilium is difficult to ascertain. It possesses characteristics of both an amphiarthrodial and a diarthrodial joint, but undoubtedly its degree of movement is quite limited which places it in the category of an amphiarthrosis, and being united by an interosseous ligament accounts for the syndesmosis classification. However, the joint does contain a syndovial sac, which structure is usually reserved for a freely movable joint, hence the possible classification as a diarthrosis. The Chiropractic inclination, based upon clinical and anatomical study, is toward that of slight movement in the sacroiliac articulation.

The auricular surfaces of the sacrum and the ilium are each covered with a layer of cartilage, thicker on the sacrum than the ilium. These cartilages are fused at irregular intervals, and their union further strengthened by interosseous fibers.

Between these cartilage surfaces is a synovial joint capsule containing synovial fluid. The sacrum and the two ilia are held together by the anterior sacroiliac, long posterior sacroiliac, short posterior sacroiliac, and interosseous ligaments.

The Anterior Sacroiliac Ligament—is thin. It consists of short fibers which connect the anterior surface of the lateral part of the sacrum to the margin of the auricular surface of the ilium. Its upper part connects the ala of the sacrum with the

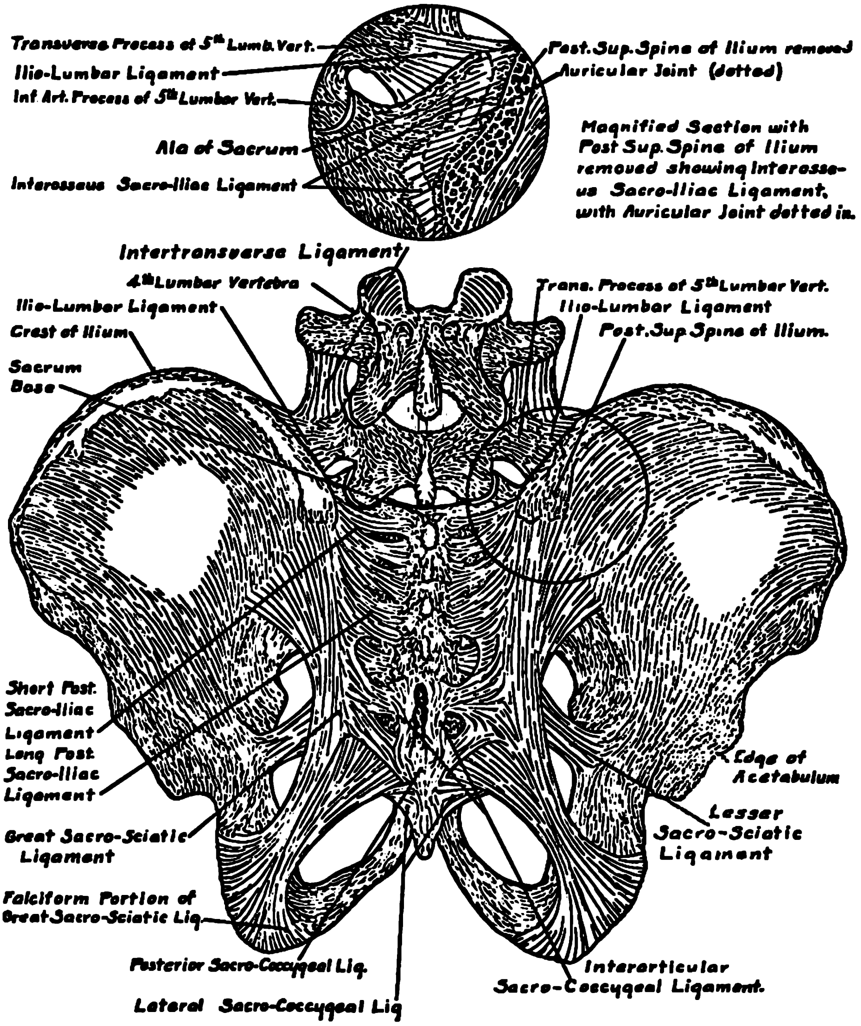


Fig. 60. Posterior view of the pelvis and lower lumbars showing the principal ligaments.

ilium; the lower part connects the pelvic surface of the sacrum with the ilium. Both parts are intimately fused with the periosteum covering the two bones.

The Long Posterior Sacroiliac Ligament—is a thick band running almost vertically from the posterior superior iliac spine down to the third or fourth transverse tubercles of the sacrum. It continues downward as the sacrotuberous (great sacrosciatic) ligament, and it is covered by the gluteus maximus muscle.

Short Posterior Sacroiliac Ligament—pursues a horizontal course from the first and second sacral tubercles laterally to the posterior surface of the ilium behind the auricular surface. It is covered by part of the sacrospinalis muscle. Collectively, the short and long posterior sacroiliac ligaments on each side form a posterior sacroiliac ligament which is very strong, and is the chief union between the sacrum and ilium.

Interosseous Ligament—is short and thick. It is the strongest of the sacroiliac ligaments as it bears the suspension of the sacrum and the body above between the ilia. It is attached to the iliac tuberosity and the corresponding surface of the sacral tuberosity above and behind the auricular surface.

LIGAMENTS CONNECTING THE SACRUM AND ISCHIUM

1. **The Sacrotuberous**
2. **The Sacrospinous**

The Sacrotuberous or Great Sacrosciatic or Posterior Sacrosciatic Ligament stretches across the lap between the sacrum and the ischium. It is flat and triangular in form, being broad at both ends and narrow in the middle. Superiorly it is attached by its broad base to the posterior inferior iliac spine, third, fourth, and fifth transverse tubercules of the sacrum, and the lateral border of the coccyx. The ligament passes obliquely downward, forward and lateralward, becoming narrow and thick until just before its insertion it widens once again. Inferiorly, it is attached to the medial margin of the tuberosity of the ischium, and is continued as a narrow band, the **Falciform Process**, along the ramus of the ischium.

Relations of the Sacrotuberous Ligament

The posterior surface gives origin to a part of the gluteus maximus muscle. Its anterior surface lies next to the pyriformis

muscle and gives origin to a part of the muscle. The anterior surface is also united to part of the sacrospinous ligament and the obturator internus muscle.

Its superior border forms above, the posterior boundary of the greater sciatic foramen; and below, the posterior boundary of the lesser sciatic foramen. Its inferior border forms a part of the boundary of the perineum. The sacrotuberous ligament is pierced by the coccygeal branch of the inferior gluteal artery and by the perforating cutaneous nerve, the fifth sacral and coccygeal nerves, and by some branches of the coccygeal plexus.

The Sacrospinous or Small Sacrosciatic or Anterior Sacrosciatic Ligament is flat and triangular. It is attached by its apex to the ischial spine, by its base to the lateral margins of the sacrum and coccyx in front of the sacrotuberous ligament with which its fibers are connected. It lies between the greater and lesser sciatic foramina and completes their boundaries.

Relations of the Sacrospinous Ligament.

The medial part of its posterior surface is blended with the sacrotuberous ligament, the lateral portion is crossed by the internal pudendal vessels and nerve. The anterior surface is blended with part of the coccygeus muscle. The ligament is pierced by the fifth sacral and coccygeal nerves and branches of the coccygeal plexus.

The sacrospinous and sacrotuberous ligaments convert the sciatic notches into the greater and lesser sciatic foramina. The **Greater Sciatic Foramen** is bounded in front and above by the margin of the greater sciatic notch of the hip bone, behind by the sacrotuberous ligament, and below by the sacrospinous ligament.

The greater sciatic foramen transmits one large muscle and several sets of vessels and nerves. The muscle is the pyriformis muscle, and above it the superior gluteal vessels and nerve pass out of the pelvis. Below the pyriformis muscle, the sciatic nerve leaves most laterally; the nerve to the quadratus femoris lies in front of the sciatic; the posterior cutaneous nerve lies medial to the sciatic; the inferior gluteal nerve medial to the cutaneous; the nerve to the obturator internus medial to the inferior gluteal; and most medial of all the pudendal nerve. The internal pudendal vessels and the inferior gluteal vessels also leave the pelvis through the greater sciatic foramen.

The Lesser Sciatic Foramen—is bounded in front by the margin of the lesser sciatic notch and the tuberosity of the ischium, above by the ischial spine and the sacrospinous ligament, and behind by the sacrotuberous ligament. It transmits the tendon of the obturator internus muscle, the pudendal nerve, the nerve to the obturator internus, and the internal pudendal vessels.

LIGAMENTS ATTACHED TO THE VERTEBRAE

Bodies

1. Anterior longitudinal—axis to sacrum.
2. Posterior longitudinal—axis to sacrum.
3. Capsular ligaments around small joints at sides of cervical bodies.
4. Capsular and radiate ligaments around facets and heads of ribs—first through twelfth thoracic.
5. Medial arcuate ligament on second lumbar.

Laminae

1. Ligamenta flava—to all the laminae.

Articular Processes

1. Capsular ligaments—around all vertebral articular processes.

Transverse Processes

1. Intertransverse ligaments—to all transverse processes.
2. Lumbo-sacral—fifth lumbar.
3. Ilio-lumbar—fifth lumbar.
4. Lumbo-costal—twelfth thoracic and first lumbar.
5. Arcuate—first lumbar.
6. Capsular—of costo-transverse joints, first to tenth thoracic.

7. Costo-transverse—of costo-transverse joints, first to eleventh thoracic.
8. Anterior and middle layers of the lumbar fascia—first to fifth lumbar.

Spinous Processes

1. Ligamentum nuchae—second to seventh cervical.
2. Supraspinous—all twelve thoracic and five lumbar.
3. Interspinous—all twelve thoracic and five lumbar.
4. Posterior layer of lumbo-dorsal fascia—all twelve thoracic, five lumbar, and sacrum.

PART TWO

THE ABNORMAL SPINAL COLUMN

Introduction

It will be seen from the study of the normal spinal column that it presents certain features common to all human spinal columns. The curves, length, bone structure, muscle and ligament attachments, and its relationship to the rest of the body should follow a set pattern. These qualifications are found within certain allowable variations, and the spinal column is thus designated as being normal.

The Science, Art, and Philosophy of Chiropractic is directed toward that spinal column which is not normal, because the presence of a vertebral subluxation with resulting interference in the transmission of mental impulses precludes the possibility of that spinal column being normal. A properly formed and aligned vertebral column does not cause nerve interference; Chiropractic studies the normal, the better to understand the abnormal.

It is recognized that the spinal column of each body displays some individuality in its anatomical make-up and this phenomenon may be termed "normal variation." However, when the spinal column has become obviously exaggerated beyond acceptable limits, then the condition may be called an anomaly or malformation.

As regard the terms anomaly, malformation, and abnormality as applied to the spinal column, all three may be considered synonymous for practical purposes. An anomaly is a marked deviation from the normal standard, and an abnormality possesses the quality of being abnormal, in other words, a malformation.

Chapter 7

SPINAL CURVATURES

The term curve is used to designate a normal deviation from a straight line in the contour of the spinal column. Normally, there are two primary and two secondary curves in the adult column. However, a curve may become exaggerated beyond acceptable limits, and it is then referred to as a spinal curvature; thus a curve becomes abnormal, and is called a curvature. A curvature, then, is an abnormal curve, showing a marked deviation from the normal standard.

It is customary to name the curvatures according to the direction in which the spinal column is bent. Basically, there are three primary spinal curvatures: scoliosis, kyphosis, and lordosis. There may be several possible combinations of these, along with rotation of the involved spinal segments, such as rotatory scoliosis, or a lordotic rotatory scoliosis.

Spinal curvatures may also be classified in another way, based upon their causation, as primary or secondary; direct or adaptative.

A primary curvature is the first abnormal bending to appear in the spinal column. It may be either direct or adaptative; direct if it is due to abnormal spinal dynamics resulting from interference to the normal transmission of mental impulses to the involved tissues, as in paralysis of deep spinal muscles following poliomyelitis; adaptative if it is compensating for some abnormality or incoordination. An example of a primary adaptative curvature might be that of the pull of adhesions from lung or rib diseases. There are many possible reasons for a primary curvature being either direct or adaptative.

A secondary curvature is always adaptative to a primary curvature and is an attempt toward compensation by the shifting

of the body's center of gravity back to normal after it has been lost by the appearance of the primary curvature.

If a primary curvature develops in the lumbar area, it is usually only a matter of time until a secondary curvature will appear in the thoracic region to adapt to, or compensate for, the primary curvature. Just how many vertebrae will be involved, and the degree of involvement, will depend upon Innate's precise analysis of the condition, and making the best of a bad situation —Intellectual adaptation.

SCOLIOSIS

The term scoliosis refers to a lateral curvature of the spine. It is named according to the direction of the convexity; i.e., if the convexity is directed to the left, it is a left scoliosis. If the entire spine is involved, it is a total scoliosis, and may be either right or left total scoliosis. If only a part of the spine is involved, it is named according to the region affected, such as a cervical scoliosis, cervico-dorsal scoliosis, dorsal scoliosis, lumbo-dorsal scoliosis, and lumbar scoliosis. These may also be designated as right or left, such as left cervical scoliosis, right thoracic scoliosis, etc.

Rotatory Scoliosis or Rotary Scoliosis is a lateral curvature of the spine with a rotation of the involved vertebrae. A scoliosis is almost invariably accompanied by some rotation of the vertebral bodies concerned, and usually the bodies are rotated in the direction of laterality of the curvature. In a right rotatory scoliosis, the convexity of the curvature is toward the right, and the bodies of the vertebrae involved are rotated toward the right which tends to shift their spinous processes left of the median line of the vertebral bodies. In certain extreme cases of rotatory scoliosis, the rotation may be so great as to draw a series of transverse processes into positions beneath the skin normally ascribed to the spinous processes. Such malpositions may be misleading in making a spinal analysis.

Inspection and palpation of a person exhibiting a well-defined rotatory scoliosis will present a series of abnormal findings. Assuming the apex of the right rotatory scoliosis to be in the mid-dorsal region, we would expect to find the following: a secondary compensatory curvature to the left in the lower dorsal and upper lumbar regions, and a secondary compensatory curvature to the left in the upper dorsal and lower cervical regions; the

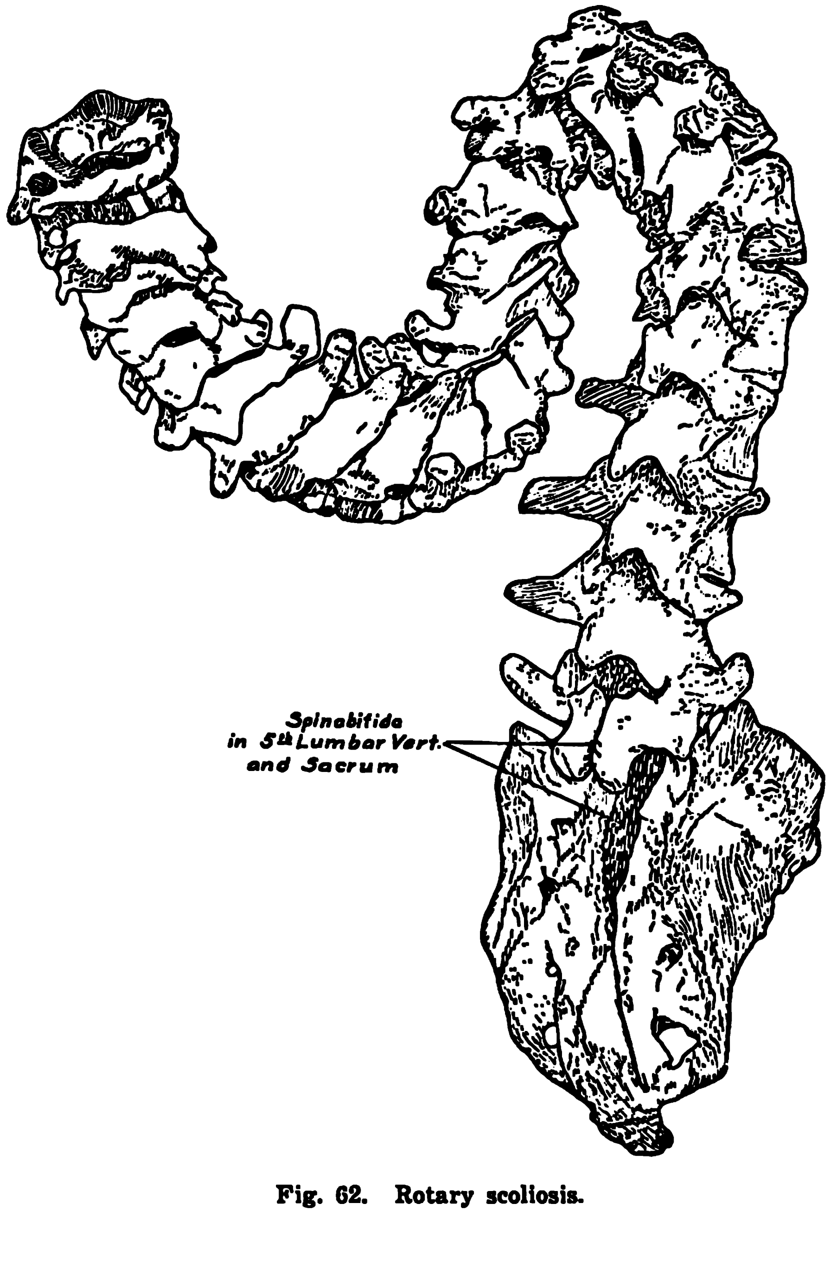


Fig. 62. Rotary scoliosis.

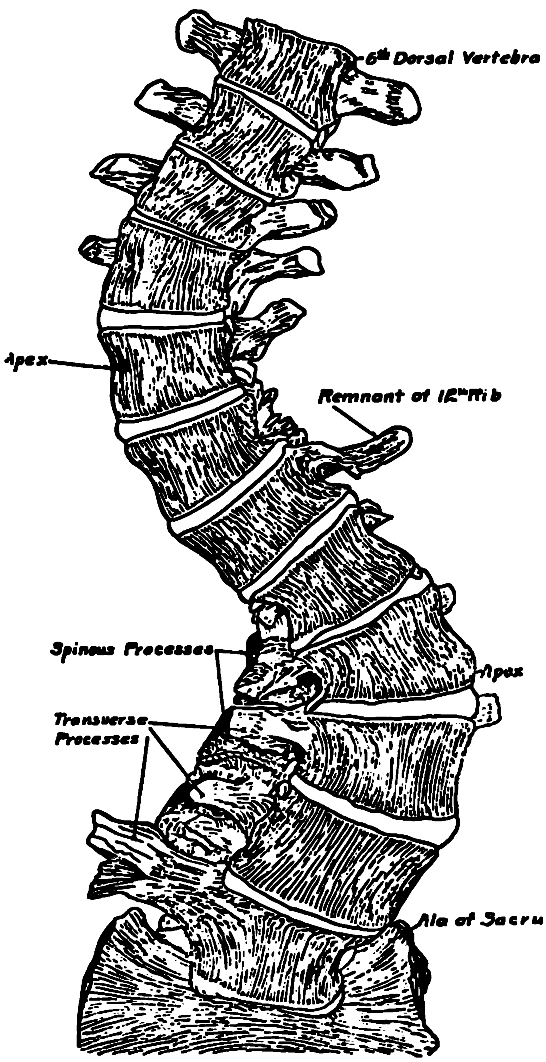


Fig. 61. Double scoliosis—anterior view.

left shoulder lowered with the scapula closer to the midline, the left side of the thorax flattened and depressed, and the left hip prominent. The right shoulder is elevated, with the scapula away from the spinal column, the right side of the thorax is bulging, and the ribs run horizontally. In the case of a left rotatory scoliosis in the mid-dorsal region, these findings would be reversed.

Causes of Scoliosis—The more common causes of scoliosis include habits, posture, occupation, congenital anomalies of the vertebral column, disturbances of nerve supply to spinal muscles and other local tissues, rickets, and extravertebral contractures and pressures. Besides these, many other factors may have a direct or indirect effect upon the production of a lateral curvature of the spine.

Types of Scoliosis

1. **Habitual or Idiopathic Scoliosis**—is usually the result of improper positions of the body over a long period of time. It accounts for 80 to 90 per cent of all scoliosis cases. Habitual scoliosis seldom, if ever, produces pathological changes in the vertebrae, although the vertebral bodies do show the development of wedge-shaped deformities.

In most cases, the primary lateral curvature is accompanied by one or two compensatory curvatures, with the primary curvature appearing about the tenth year of life, and gradually the spinal column twists into multiple scolioses which become pronounced and obvious during adolescence.

The usual habitual scoliosis is almost always a combined rotatory scoliosis, the rotation of the vertebrae keeping pace with the increase of the lateral curvature. It seems that the mid-dorsal region is the one exhibiting the primary curvature apex in the overwhelming majority of cases.

(a) Causes of Habitual Scoliosis

The possible causes of habitual scoliosis are many, and they may be either physical or psychological; poor lighting, the wrong type of chair, the wrong type of bed, and such other environmental factors as may be conducive to poor habits of spinal balance are among a few of the physical reasons. Among children, the processes of growth often lead to faulty habits of posture. Too rapid growth may result in slouching. Oftentimes, the

attempt on the part of a tall child to not be conspicuous will lead to poor postural habits which become habitual. As time goes on, the habit becomes so deeply ingrained that the spinal column adapts to the abnormal positions into which it is continually forced, and finally the abnormal becomes normal and a permanent scoliosis results. Probably the single greatest contributing factor to a habit scoliosis, or for that matter, to any spinal curvature, is that the individual has no normal posture constant—in other words, a lack of posture consciousness.

(b) Vertebral Changes in Habitual Scoliosis

The outstanding change in the vertebrae responsible for a lateral curvature is the development of a wedge-like deformity of the vertebral body. This wedging occurs in a transverse direction so that the vertebral body becomes thinner on the side opposite to the scoliosis. The neural arches of the involved vertebrae are likewise deformed, and the articulating processes are drawn out of their proper alignment with a consequent locking of the vertebrae in their abnormal relationships.

Most cases of habitual scoliosis may be attributed to the fact that bone is plastic and easily molded during the early years of life. If the individual develops poor habits of spinal hygiene and posture, the result may be deformity of the spinal column. After such a spinal defect has become "set" with subsequent body adaptation to it, the outlook for correction is poor. The best method of dealing with a scoliosis and other spinal curvatures is **prevention** by advocating regular Chiropractic check-ups on children and adolescents, and by promoting such campaigns as will make the layman posture-minded.

2. Occupational Scoliosis

The occupations of many people lead them into poor posture and curvatures of the spine, particularly that of a scoliosis. An occupational curvature is adaptative to the occupation of the individual; consequently, a change of occupation may do much to correct the curvature, or else proper instructions as regards the actions and posture of the individual may help to minimize the deforming factor.

Essentially, the occupational scoliosis is an adaptation process to an abnormal strain or position, and, in time, the adaptation becomes permanently established as a scoliosis or other spinal

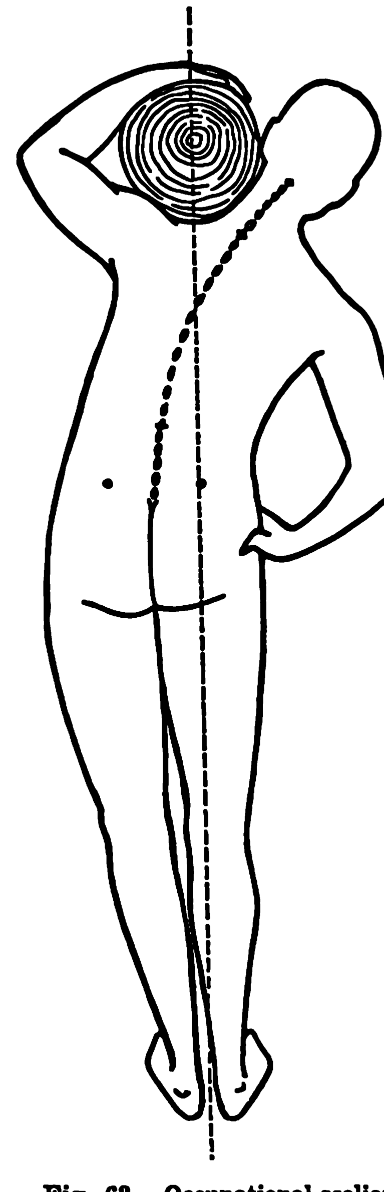


Fig. 63. Occupational scoliosis.

curvature. Any occupation that calls for long hours over a desk or bench is a threat to good spinal alignment. Railroad engineers, musicians and truck-drivers are only a few among the many occupational groups subject to spinal curvatures.

It must be admitted that a concerted scientific effort to correct the occupational causes of spinal curvatures is gradually bearing fruit, and this program, coupled with the extensive endeavors of the Chiropractic profession to educate young America to grow tall and straight, will do much to eradicate the problem.

3. Static Scoliosis

A difference in the length of the legs may lead to a lateral spinal curvature known as a static scoliosis. This of course is an adaptative attempt to equally distribute the weight of the body. In the initial stages of leg length inequality, there may be merely lateral compression of one side of the intervertebral discs, but in time the typical transverse wedging of the vertebral bodies may appear. Among the more common reasons for a shortening of one of the legs are hip joint disease, Legg-Perthe's disease, fracture, and congenital dislocations of the hip. A scoliosis due to hip-joint disease is also called Ischiatic Scoliosis or Coxitic Scoliosis. As these conditions become chronic, so will the static scoliosis, and eventually the changes in the vertebral bodies will preclude any worthwhile correction of an unfortunate situation.

4. Paralytic Scoliosis or Myopathic Scoliosis

Certain forms of paralysis affecting the muscles of the spinal column will in time produce a scoliosis. In poliomyelitis, the scoliosis may appear only a few months after the acute stage of the disease and be rapidly progressive. In other diseases, such as progressive muscular dystrophy and pseudohypertrophic muscular paralysis, the development of the scoliosis proceeds more slowly—oftentimes several years elapse between the onset of the disease and the appearance of the curvature.

It is known that each muscle of the spinal column has an antagonist which pulls in the opposite direction. If one of the pair becomes weakened by a paralytic involvement, the resulting imbalance will throw the spinal column out of its proper position. It becomes increasingly obvious that an interference with the nerve supply to the spinal musculature will produce drastic

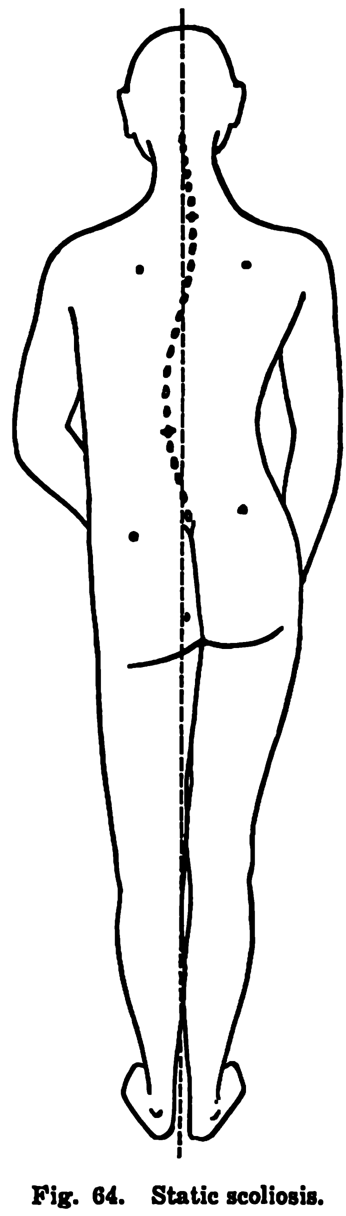


Fig. 64. Static scoliosis.

changes, particularly of a scoliotic nature; whether or not the paralysis is named as a specific disease makes no difference in the outcome.

The best prevention and the best correction rests with restoration of normal nerve impulse supply to the involved muscles through the medium of adequate, scientific Chiropractic care.

5. Ophthalmic Scoliosis or Ocular Scoliosis

This is a lateral curvature primary to the cervical region resulting from continually holding the head in a tilted position to accommodate for various eye disorders such as astigmatism. In many cases the scoliosis will be very pronounced; in addition the individual not only tilts the head, but rotates it as well in an endeavor to see as fully as possible. The curvature then becomes adaptative to the underlying visual disturbance. Clinical results indicate a rapid improvement in the curvature condition once the eye condition is corrected which would indicate a lack of bony distortion of the vertebral bodies. This change for the better prevails in the majority of cases, but not all.

6. Rachitic Scoliosis

Is due to rickets. This disease is notorious for the bone malformation it produces and the spinal column is one of the regions most seriously affected. Because of a deficiency in mineral content of the vertebrae, these structures are unusually soft and compressible with a marked tendency toward deformity from pressure and weight-bearing.

7. Cicatrical Scoliosis

Is due to the pull of a scar or adhesions following disease of the bony vertebrae or adjacent tissues. A deformity in the dorsal region may result from extensive adhesions formed by a healed lesion of the lung pleura pulling on the thoracic vertebrae. Such a condition is sometimes called an Empyematic Scoliosis. Any disease of the spinal ligaments or muscles, such as an abscess, may heal with extensive scar formation which exerts a continuous tension upon local vertebrae and finally brings about a cicatrical scoliosis.

8. Osteopathic or Inflammatory Scoliosis

Results from disease of the vertebrae. Pathology in the bone tissue may cause extensive deformity of the vertebrae

with resultant loss of normal spinal contour and so a curvature is produced. Among the causes of osteopathic scoliosis may be included tuberculosis of the spinal column, Paget's disease, osteoporosis, arthritis, and rickets.

9. Sciatic Scoliosis or Brissaud's Scoliosis

The patient suffering with sciatica assumes a typical standing position in which the back is flat, the lumbar muscles are rigid, and the lumbar region and thorax are tilted away from the affected side. Should the sciatica become chronic, the scoliosis develops as a means of relieving the discomfort and the scoliosis may also become chronic. Fortunately, the results obtained on sciatica through Chiropractic are usually excellent, and the danger of a permanent sciatica scoliosis is remote in the great majority of such cases.

10. Surgical Scoliosis

This type of scoliosis may follow thoracoplasty or other operations in tissues proximal to the spinal column. The removal of ribs or muscles frequently results in weakening of the affected side so that the equilibrium of the spinal column is lost and a scoliosis appears. In most cases there is little apparent deformity of the vertebral bodies. Instead, the curvature is a consequence of the pull of unopposed muscles.

11. Radiation Scoliosis

Extensive radiation therapy directed to the spinal column may seriously retard epiphysical growth and produce lateral curvatures in the growing child. In this type, the bone tissue is interfered with in its growth, and inequalities of the vertebrae permit the formation of a curvature. Improper and prolonged X-ray and radium therapy have been mentioned as causative factors.

12. Congenital Scoliosis

In congenital scoliosis, it is assumed that the child is born with the deformity, or at least the major contributing factor is present at birth and the scoliosis will not be long in making its appearance once the upright posture is assumed.

The usual cause is the formation of wedge-shaped hemivertebrae due to a developmental failure or arrest. The wedge-

shaped hemivertebra develops between two normal vertebrae and produces a curvature of the spine. It this occurs in the thoracic region, there may be a corresponding deformity of the chest. When the lesion is in the lumbar region, there will be increased prominence of the Sacrospinalis muscles on the side of the convexity when the person bends forward from the hips. Also, the curvature becomes more apparent upon bending forward. Not infrequently, the trouble in the lumbar type of congenital scoliosis is due to malformation or tilting of the fifth lumbar on the sacrum.

13. Disease of the Spinal Cord and Scoliosis

The presence of tumors, cysts, angiomata, adhesions, and similar extramedullary lesions is frequently manifest by the appearance of a scoliosis. The curvature usually points toward the side of the spinal cord disease. Undoubtedly most of these cases are the direct result of nerve root compression interfering with proper balance of the spinal musculature.

KYPHOSIS

A kyphosis is an abnormal backward angulation or curve of the spinal column. The convexity of the curvature is directed posteriorly, and it occurs most frequently in the thoracic region. Kyphosis may be classified as primary or secondary, direct or adaptative; with the basis of such classifications being the same as applied to a scoliosis or other spinal curvature.

The degree of curvature will vary from a mild dorsal convexity to that of a semi-circular shape of the thoracic region. Frequently, there is a noticeable "hump" on the back, and the term "hunch-back" is commonly used to denote the condition.

Causes of Kyphosis

Many of the same factors which contribute to the formation of a scoliosis, lordosis, or other spinal curvature also are concerned with the development of the kyphotic spinal column. A primary kyphosis may form as the result of local weakness of the adjacent spinal musculature, as in poliomyelitis. A secondary kyphosis may become adaptative to other curvatures resulting from poor posture. Occupation is a third important reason responsible for this condition. In fact, once again we meet the notorious trio of weak spinal structures, poor posture,

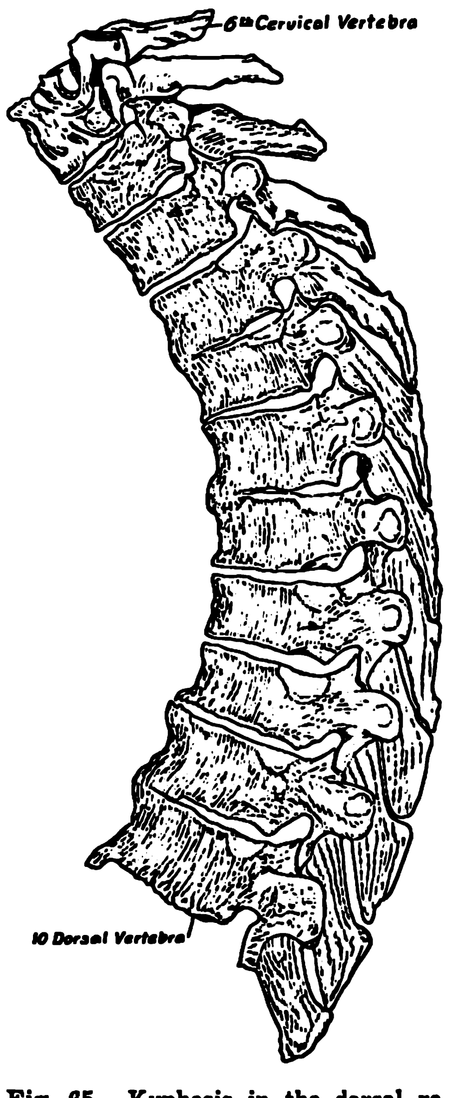


Fig. 65. Kyphosis in the dorsal region showing adaptative exostosis and ankylosis.

and occupation as major contributing factors to most spinal curvatures. This is especially true as regards those kyphoses where the curve is gradual rather than a sharp angulation. Where there is a definite angular break in the continuity of the thoracic curve, the underlying cause is usually a pathological process which is involving the vertebral bodies, intervertebral discs, and other spinal tissues. Tuberculosis of the spinal column ("Pott's disease"), syphilis, osteomyelitis, rickets, arthritis, Paget's disease, osteoporosis, cancer, fractures, and congenital anomalies are all possible causes of kyphosis. These conditions will be discussed under their respective headings.

Another interesting type of kyphosis is known as "adolescent kyphosis" seen in adolescent children. The curvature is very pronounced and is most often found in the dorsal region. It is associated with vertebral epiphysitis. The deformity produces fatigue, vague backache, and an awkward gait. The deformed region of the spine is painful and tender to pressure, and pain commonly radiates into the legs.

Pulmonary emphysema frequently produces a thoracic kyphosis accompanying the typical chest enlargement in all directions, the so-called "barrel-chest." The great increase in the size of the lungs encroaches upon both the thoracic wall and the thoracic vertebrae and forces them outward.

LORDOSIS

A lordosis is an abnormal forward curving of the spinal column. In this condition, there is an exaggerated convexity of the spine directed to the anterior, and the most common sites are the lumbar and cervical regions. Lordoses are classified as primary or secondary; direct or adaptative. By far the largest percentage of these curvatures is adaptative which is demonstrated in certain enlargements of the abdomen such as pregnancy, ascites, and tumorous enlargements of the spleen or liver. A primary lordosis frequently results from weakness of the back muscles from causes such as poliomyelitis or progressive muscular dystrophy. In the latter condition, there is generalized weakness of the spinal muscles with eventual marked lordosis of the spine while the patient is still ambulatory. Finally, when the patient is no longer able to walk and is confined to a wheel-chair, an extreme scoliosis gradually develops.

A lordosis may be adaptative or secondary to a kyphosis in some other region of the spine. It is formed principally by an attempt on the part of the body to establish a normal center of gravity, and the only discernible change in the spinal structure is a thinning of the posterior portions of the intervertebral discs. Poor posture is the number one cause of this anterior spinal curvature. In most cases of lordosis resulting from poor posture or relaxation of muscular support no gross changes can be seen in the vertebral bodies or the intervertebral discs. In fact, of the three fundamental spinal curvatures, kyphosis, scoliosis, and lordosis, the latter is least apt to show structural changes in the spinal tissues.

An example of bone deformity yielding an exaggerated lordosis is seen in the case of an achondroplastic dwarf in which there is an early interference with bone development resulting in statural retardation.

Pregnancy affords an excellent illustration of the adaptative powers of the human body in that the lumbar curve is much exaggerated during the latter half of pregnancy, only to resume its normal curve soon after parturition. This might correctly be termed a physiological lordosis.

CHIROPRACTIC AND THE SPINAL CURVATURE

The Chiropractor knows that every spinal curvature has a cause; whether the deformity be primary or secondary, direct or adaptative. The correction of these curvatures resolves itself into finding the cause and correcting the cause, which procedure will, in turn, effect spinal normalcy; providing, of course, that the condition has not exceeded the limitations of matter.

A Chiropractor is not a spinal architect nor a spinal mechanic, and should work through the Innate Intelligence of the body involved to bring about results rather than attempting to manually shape the spinal column. Obviously, the prognosis is better in a case due to muscular weakness than in one resulting from tuberculosis of the vertebrae, but approach to both is the same—correct the interference to nerve transmission which is bringing about the deformity. Considering the infinite number of muscular combinations and other factors which play upon the spinal column both directly and indirectly, it becomes evi-

dent that the alignment of the spinal column by a purely mechanical approach is absurd. Vertebrae are not building blocks to be shoved hither and thither, but rather, they are integrated parts of a living body and, as such, have a guiding force to repel detrimental forces as well as to accept those concussions of force scientifically applied.

The well-trained Chiropractor sees evidence of internal forces at work in every case undergoing a correction of spinal curvature. The pulling of muscles, the heat, the tenderness, the pain, the cramping, are all common signs of Innate forces at work correcting the deformity. The best attitude to adopt in such circumstances is one of "optimistic expectancy" because, in due time, normalcy will replace abnormalcy.

In many cases, particularly those colored by postural or occupational causes, the Chiropractor will do well to work with the Educated of the patient as well as with the Innate. What value is the subscribing to posture-weeks, posture-contests, and similar approaches to the indoctrination of spinal consciousness if this program is not continued in the daily practice?

Chapter 8

EXOSTOSIS AND ANKYLOSIS

The terms exostosis and ankylosis are frequently used in describing certain abnormalities of the spinal column, and in many instances, the inference is made that they are synonymous; actually they are not.

Exostosis is also known as hyperostosis, and is a condition in which there is a bony growth projecting outward from the surface of a bone. This growth need not connect to an adjacent bone, but rather, it may end in soft tissues. For example, a calcaneal spur is an exostosis. The vertebrae, mandible, palatine bones. and tarsals are particularly prone to develop exostotic formations which, in reality, are a form of benign osteoma.

Ankylosis is the abnormal consolidation and immobility of a joint. In this condition, all or part of the joint tissues are involved in changes which unite two or more articular structures. Motion in the affected joint is finally interfered with.

Thus, it will be seen that an exotosis may not produce an ankylosis in some instances, and it is possible to have an ankylosis without an exostosis being present. Of course the great majority of exostotic growths affecting the vertebrae will sooner or later result in ankylosis of the involved structures. Whether or not either or both of these conditions will prevail can generally be based upon the underlying reason for the exostosis or ankylosis.

Types of Exostosis—Fundamentally, there are two main types of exostosis—true and false.

1. **True Exostosis**—is a condition in which there is a development of true bone tissue projecting outward from the surface of a bone.

2. **False Exostosis**—is a condition in which bone tissue is softened and molded into abnormal shapes, but no new bone is formed.

In true exostosis it is found that disturbance of bone formation is the reason for the excessive bone development. The periosteum is involved and proliferation of bone cells is without proper control. This is evidently not always the case, however, as true exostosis is often adaptative to spinal abnormalities or functional stresses. A good example of heavier bone formation adaptative to functional needs is to be seen in the difference between the male and female skeleton. Although not an exostosis, the bony processes are heavier and larger on the male skeleton for the more secure attachment of muscles designed for greater muscular effort.

(A) Types of True Exostosis

The classifications of true exostosis are based upon the reasons for the bony growth.

1. Adaptative Exostosis

This occurs primarily on the spinous processes and is for the purpose of strengthening these structures. It may occur on any bone in the body. An adaptative exostosis is frequently found in the spinal column involved in a curvature. Innate Intelligence develops the bony overgrowth to hold the involved vertebrae firmly, and to prevent the curvature from becoming more exaggerated. In these cases the exostoses are most often found on the bodies of the vertebrae; partly because of the large amount of cancellous tissue making them more susceptible to such changes, but more particularly because the bodies of the vertebrae support the weight of the trunk.

The formation of exostosis on the vertebral bodies with a resultant ankylosis will strengthen the vertebral column, but there will be a loss of movement in the joints involved. Another frequent site of hyperostosis is the transverse processes, which is an adaptative measure to strengthen the spine and control motion which might otherwise be detrimental.

Since an adaptative exostosis is a process of Intellectual adaptation on the part of Innate Intelligence to compensate for an abnormal condition, it follows that correcting the cause of the

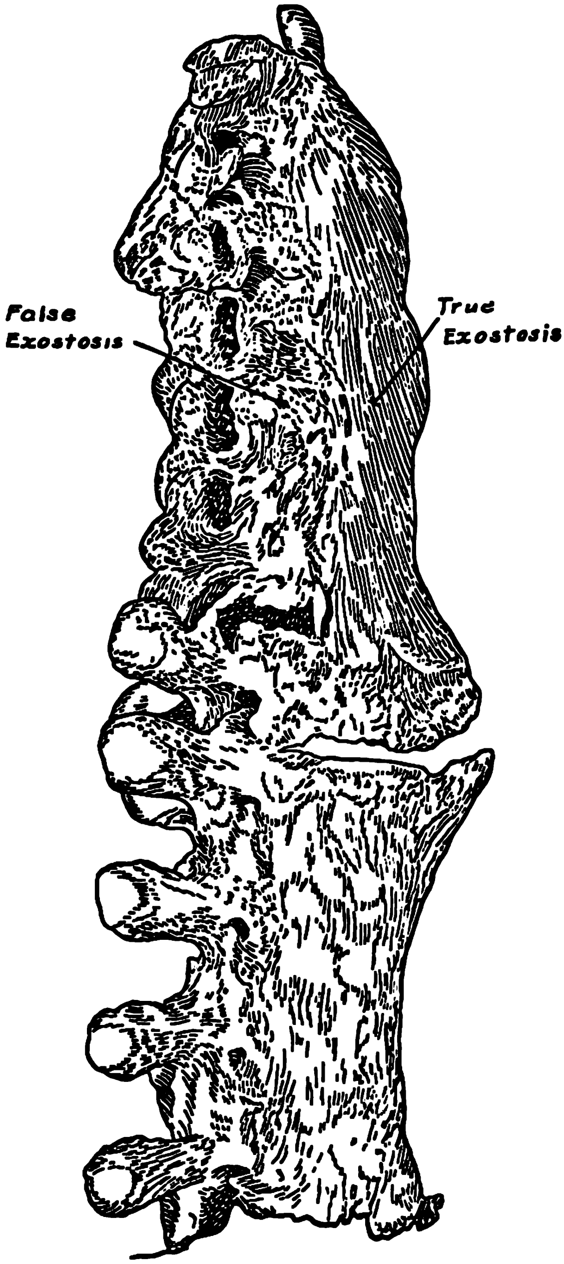


Fig. 66. Cervical and upper dorsal regions showing true and false exostosis and ankylosis.

exostosis will, in turn, result in readaptation. If the Innate of the body involved deems it necessary, there will be resorption of the bony growths. For example, if a severe scoliosis has formed due to weakness of the spinal muscles caused by interference with transmission of mental impulses, then Innate may, in time, build an exostotic growth. When normal transmission of mental impulses is restored, and the muscles regain normal tonus, then the scoliosis and the exostosis may both be eliminated. Such changes will depend upon the extent of exostosis, and particularly upon the degree of ankylosis, as well as the time factor. It would be expecting too much to anticipate correction of such a condition of twenty or thirty years' standing.

2. Inflammatory Exostosis

Inflammation of the bone may primarily involve the cancellous bone and marrow, compact bone or periosteum, giving rise to osteomyelitis, osteitis, and periostitis, respectively. In most cases, all the structures of the bone are involved in the inflammation. It should be remembered that the underlying mechanism of inflammation in bone is in no manner different from that of inflammation in other tissues, the difference in results being due to the peculiar structure of bone.

A true inflammatory exostosis is characterized by the formation of excessive new bone cells due to disturbance of the periosteum and its osteogenic layer. Obviously the line between a true inflammatory exostosis with new bone cell proliferation and a false inflammatory exostosis with rearrangement of the bone already present is a matter of degree of inflammation. Osteitis, arthritis, or periostitis, to name a few inflammatory bone diseases, may produce either a true or false condition depending upon the heat and other inflammatory processes.

3. Traumatic Exostosis

Trauma is responsible for a great many exostotic growths in the body. The callus which forms at the site of a fracture is a bony overgrowth laid down by Innate to strengthen the affected parts. The vertebral spinous processes are particularly prone to show exostotic formations from blows or falls because of their relatively exposed position beneath the skin of the back.

(B) Types of False Exostosis

False exostosis, with its enlargement and distortion of

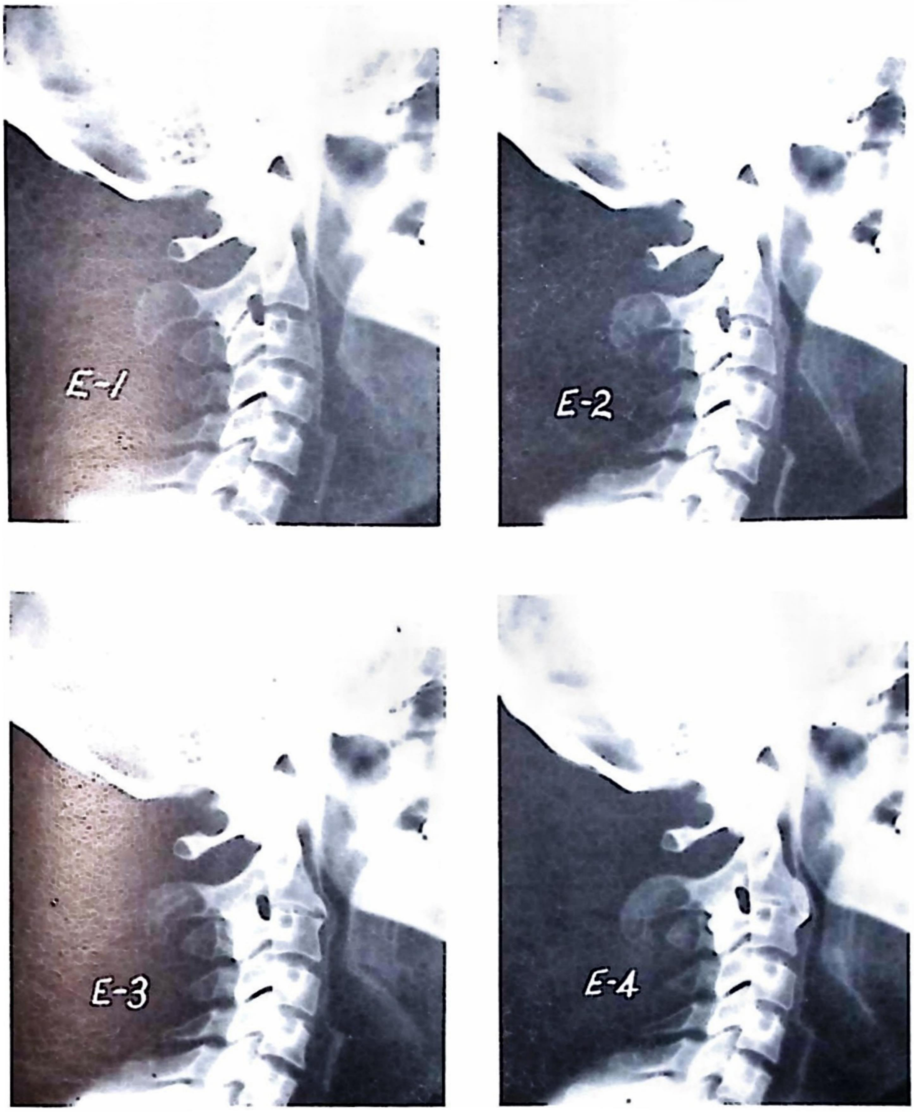


Fig. 67. Series of lateral cervical views taken at intervals of six months.

Note the exostosis forming on the anterior-inferior surface of the axis body and its ultimate fusion with the spur arising from the anterior superior surface of the third cervical body.

bone, may be classified into a single group—namely, **pathological.** In this condition there are extensive changes in the morphology of the vertebrae, particularly in the vertebral bodies, resulting from severe diseases of the bone tissues. In some diseases the febrile reaction may be so great as to soften the bone and the weight of the trunk may cause a bulging or distortion of the vertebral bodies. In other diseases the destruction of bone tissue may be followed by an overgrowth so extensive that the vertebral structures involved may be fused into a solid misshapen mass so distorted as to be unrecognizable. A few of the more common pathologies apt to produce false exostoses include tuberculosis of the spine (Pott's disease), ankylosing spondylitis, arthritis of the spine, spondylosis, and syphilis.

Chiropractic and Spinal Exostosis

Many cases showing extensive false exostosis are beyond any possible hope of correction as regards the deformity because the involved portion of the spinal column becomes a solid ankylosed mass. The malformations on the vertebrae can be very misleading in palpation, and an attempt to complete a spinal analysis by such palpation is not only confusing but is also inaccurate.

All cases under Chiropractic care should be x-rayed prior to adjustment, and this is particularly true in the presence of such extreme variables as exostotic growths. For the proper adjustment of such conditions, reference should be made to such sources as Volume XIII, Palmer Technique of Chiropractic.

(C) Unusual Types of Exostosis

There are several other types of exostosis occurring in the body which are classified according to the particular tissues involved.

1. **Exostosis Bursata**—is an exostosis from the epiphyseal portion of a bone, and is made up of bone and cartilaginous tissue which are enclosed within a fibrous connective tissue capsule. This type is sometimes seen on the articular surfaces of the vertebrae.

2. **Exostosis Cartilaginea**—consists of a layer of cartilage developing beneath the periosteum of bone. It may appear in the region of the intervertebral disc.

3. **Ivory Exostosis**—is merely a bony growth of great density. It is observed at times on the lips or lateral surfaces of the bodies of the vertebrae.

Types of Ankylosis

There are two basic forms of ankylosis—true and false.

1. **True Ankylosis**—is also known as bony ankylosis. It is a condition in which there is consolidation of a joint due to abnormal union of the bones of a joint.

2. **False Ankylosis**, or spurious ankylosis, is also known as extracapsular ankylosis and is due to rigidity of the parts surrounding a joint. It frequently results from calcareous infiltration of the ligaments and the muscles surrounding the articulation. This type may include fibrous ankylosis due to the formation of the fibrous bands within a joint, and ligamentous ankylosis in which the ligaments stiffen and tend to bind the articulations too tightly.

Causes of Ankylosis

The spinal column is particularly susceptible to ankylotic formations, serving as it does to support the trunk and permit full motion of the central axis of the body. Chiropractic observes great numbers of such cases in routine spinal examinations, and it is necessary to reach a conclusion as to whether the fixation and hypertrophy of the joint is adaptative or pathological. In either instance, the Chiropractic approach is the same, but the prognosis will be influenced by whether the ankylosis is acting as a support to a joint, or whether it is an effect of abnormal function in the joint tissues.

Many cases of ankylosis are purely adaptative to the abnormal spinal column in which the joints are fixed for the purpose of providing support to weakened tissues, or to limit motion which might otherwise injure adjacent structures.

On the other hand, the undermining and destruction of the vertebra is followed by an Innate response to "patch up" the destroyed area by laying down extensive ankylosis. In any event, we can rely upon the wisdom of an Innate Intelligence to provide the best solution possible if she is able to properly express herself over nerve pathways free of interference.

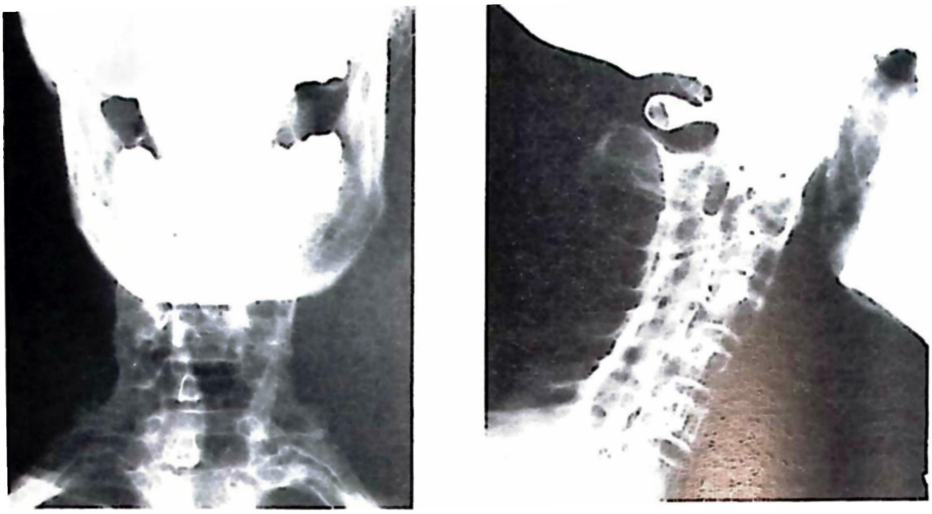


Fig. 68. A to P and lateral cervical views showing extensive ligamentous ankylosis. Note infiltration into surrounding tissues.

Fig. 69. A true exostosis arising on the third lumbar and the beginning of same on the fourth lumbar. Note the spurs on the right sides of the vertebral bodies.

Perhaps the classic example of ankylosis involving the spinal column is Ankylosing Spondylitis, or Marie-Strumpell disease discussed in detail elsewhere. This disease is characterized by a slow progressive ankylosis which may eventually involve the entire spinal column. Pott's disease is also classic in its ankylotic reaction.

Other pathological causes of ankylosis include those responsible for exostosis, arthritis of the spine, syphilis, oseomyelitis, osteitis deformans, etc.

Surgical Ankylosis is also known as artificial ankylosis or arthrodesis. It is the surgical fixation or immobilization of a joint. Such procedures are commonly employed in the surgical treatment of ruptured intervertebral discs in which a bone transplant is attached to the involved vertebrae, and in time there may be fusion throughout the immediate area.

Chapter 9

CONGENITAL DISORDERS OF THE SPINAL COLUMN—MALFORMATIONS

A congenital disorder is one existing at the time of birth, or before birth. The human spinal column seems to come in for more than its share of such anomalies, but possibly this is due to its comparative complexity, mobility, and exposed position. Then too, it is one of the initial embryonic structures to appear so that a defective germ plasm will produce a definite variation from normalcy. In fact, detailed study of the column reveals a structure of such infinite integration that to plan all its components towards developing normally is beyond Educated comprehension.

Most congenital disorders of the spinal column will be seen to consist of several categories that can be broken down into those ways in which imperfect development departs from normality.

1. **Developmental failure,** in which the embryonic structures of the spinal column fail to appear or fail to develop to any degree. Example: the absence of a vertebra.

2. **Developmental arrest,** in which the development falls short of its normal degree. Example: a condition of spina bifida.

3. **Developmental excess,** in which the normal number is increased. Example: the presence of thirteen dorsal vertebrae.

4. **Atypical differentiation,** the spinal column is imperfectly developed as compared to that of the normal fetus or infant. Example: osteogenesis imperfecta, characterized by unusually brittle bone structures developing during intrauterine life.

The ratio of incidents of congenital anomalies of the spinal column has not been statistically expressed, but Chiropractic experience has shown that such disorders are relatively frequent.

Some idea of the relatively high rate of occurrence may be obtained by considering that one live-birth in fifty shows an obvious external malformation; and internal, concealed disorders are more frequent. Of course, all of these are not concerned with the spinal column, but a goodly proportion does involve this structure. It has been estimated that as high as 40 per cent of all spinal columns show some type of anatomical variation.

A. MALFORMATIONS OF THE CERVICAL REGION

1. Klippel-Feil Disease (Congenital Synostosis)

This lesion of the cervical spine causes a fusion or malformation of the cervical vertebrae, or there may be the congenital absence of one or more vertebrae. The head will appear low between the shoulders, and the condition is sometimes described as "no neck." Fusion of the lower cervical vertebrae into one mass of bone is a common finding, and such segments as are free in the upper cervical region are usually grossly misshapen. The shortness of the neck and the limited motion are collectively termed "Klippel-Feil Syndrome." Such cases are easily detected by Chiropractic X-rays, but some are so badly deformed and ankylosed that securing an adequate adjustment may be impossible.

The disease is essentially one of developmental failure, as many of the descriptive parts of the vertebrae are lacking.

2. Congenital Torticollis (Congenital Wry-Neck)

In this condition, the child is born with the head tilted to one side and the chin rotated toward the opposite shoulder. Although there is no malformation of the cervical vertebrae this condition becomes an important Chiropractic case because of the involvement of the spinal column. Clinical results under Chiropractic care have shown a good prognosis can be given in most of these cases because of the muscle spasm of the sternocleidomastoideus resulting from nerve interference. In some instances there is a true shortening of the muscle, but most of the contractures are the result of nerve interference suffered at the time of birth.

When the child attempts to straighten the head, the muscle on the affected side will stand out prominently. Palpation reveals extreme tension of the muscle involved, and inspection shows a pulling of the chin downward toward the affected side. Rotation, or lateral tilting of the head to the side opposite the muscle

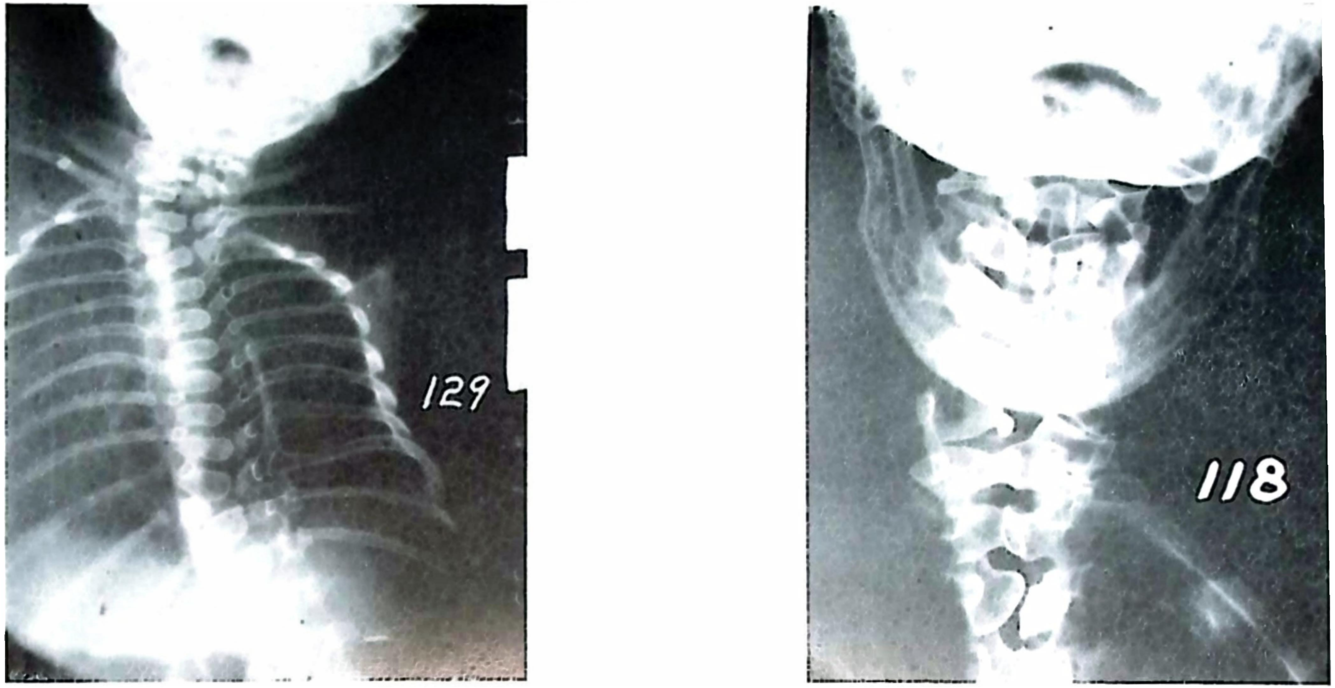


Fig. 70. Klippel-Feil Disease. The case on the left is that of a child of one year; the right illustration is from a case aged 50. Both cases show the absence of certain cervical vertebrae and those which are present show evidence of gross malformation, including spina bifida.

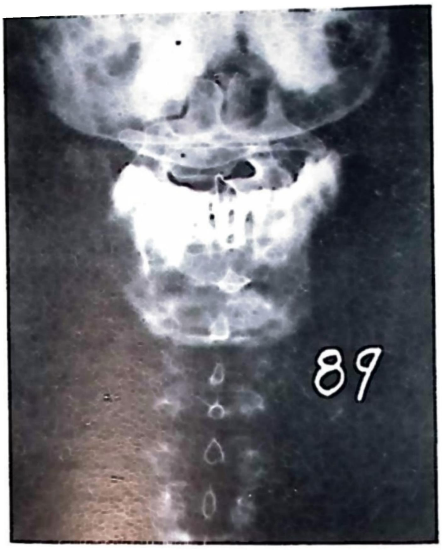


Fig. 71. Platybasia — the occiput appears to have been pushed upward, the atlas is ankylosed to the occiput, and the odontoid projects upward into the foramen magnum.

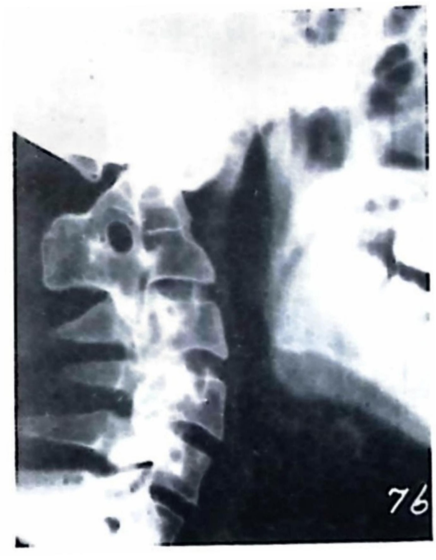


Fig. 72. Congenital fusion of the atlas with the axis—the atlas, as such, is an unrecognizable mass of bone intimately fused with the odontoid and the body of axis.

spasm, is difficult or impossible. In time a definite spinal curvature will appear; usually a scoliosis, with the convexity of the curvature away from the affected side.

3. Sprengel's Deformity (Congenital Elevation of the Scapula)

This congenital condition is another axample in which there is no malformation of the cervical or thoracic vertebrae, but there is involvement of the spinal column. In Sprengel's deformity, the neck appears to be short due to the upward displacement of the scapula, and there is a definite scoliosis of the cervical region with a compensatory curvature in the upper thoracic region.

The scapula may be raised upward from one to three inches, and is frequently rotated so badly that its upper angle may be fused to the spinous processes of the lower cervical vertebrae.

4. Platybasia

This condition is also known as **Basilar empression** and **Basilar invagination.** It is a development deformity of the occipital bone so that it appears to have pushed upward. Frequently, there is an accompanying malformation of the Atlas and Axis. The occipital condyles and the squamous portion of the occiput around the foramen magnum appear to be pushed upward so that this area presents a shallow dish-shaped concavity when viewed by A to P X-rays. The foramen magnum frequently is small and distorted, and the atlas ankylosed to the occiput at their articular surfaces.

The odontoid process of axis may project unusually high into the region of the foramen magnum, and thus create pressure upon the lower part of the medulla oblongata or the beginning of the medulla spinalis. Such direct nerve pressure may yield a number of symptoms referrable to the nervous system such as hydrocephalus, cerebellar disease, multiple sclerosis, local paralysis, and many other indications of central nervous system disturbances.

5. Occipital Vertebrae

The presence of what appears to be an occipital vertebra is not an uncommon finding. The anomally is congenital, and represents two possibilities: first, an embryonic atypical differentiation in which the sclerotomes forming the occiput are not properly incorporated in the developing bone, and second, the atlas has fused

with the occiput. In either case, there is generally distortion of the foramen magnum which may produce symptoms of direct compression of the spinal cord or medulla oblongata.

In the first form, or a true occipital vertebra, there is much deformity of the bone tissue present. Frequently, a bony ridge will form around the margin of the foramen magnum, and from this may arise rudimentary transverse processes. Usually a normal atlas will be seen below this malformation. Possibly this rudimentary neural ring is a throwback to the pro-atlas seen in certain primitive vertebrates in which the pro-atlas represents the neural arch of a "lost" vertebra the body of which has fused with the occiput.

The second form, or atlanto-occipital fusion, is manifested by fusion of the articulating surfaces of the two vertebrae. The atlas may be quite normal, although Chiropractic experience with this rather common anomaly has shown most cases to have some degree of deformity of the first cervical vertebra. Not infrequently it will be found that local ligaments and muscles show ankylotic changes adaptive to the malformations and fusion. Fusion of the atlas and occiput is also referred to as **Occipitalization.**

6. Detached Odontoid Apex

This is sometimes known as the "terminal ossicle" because it represents an accessory growth of bone just superior to the odontoid apex, and is lodged in the terminal ligament of the odontoid process. The odontoid is short and blunt, and the presence of this small bony fragment may be misleading appearing as it does much like a fractured odontoid process. In some instances it has been known to compress the spinal cord sufficiently to produce neurological symptoms, either from direct pressure on the cord, or from interference with the flow of cerebrospinal fluid.

7. Congenital Absence of Odontoid Process

This anomaly is relatively rare, but is seen occasionally in routine Chiropractic analysis. Most cases will in time show an adaptive local ankylosis to compensate for the increased and potentially dangerous mobility between atlas and axis, resulting from the loss of an articular surface. The condition represents developmental failure in which the center for the odontoid failed to grow properly. Some of these cases have been adjusted Chiropractically with satisfactory results, although the danger of dislocations of axis and of atlas due to the loss of the important

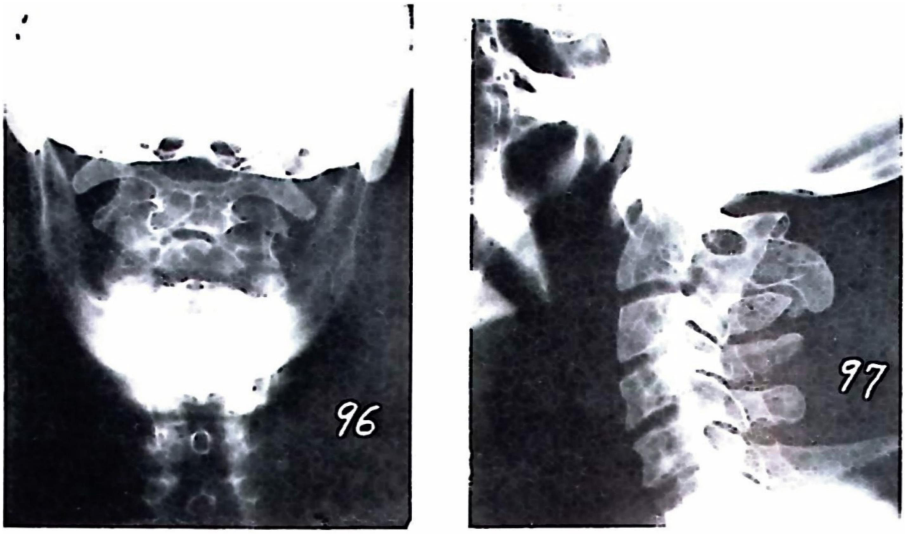


Fig. 73. A. to P. and lateral views illustrating congenital absence of the odontoid process and fusion of the atlas and axis into a single amorphous vertebra.

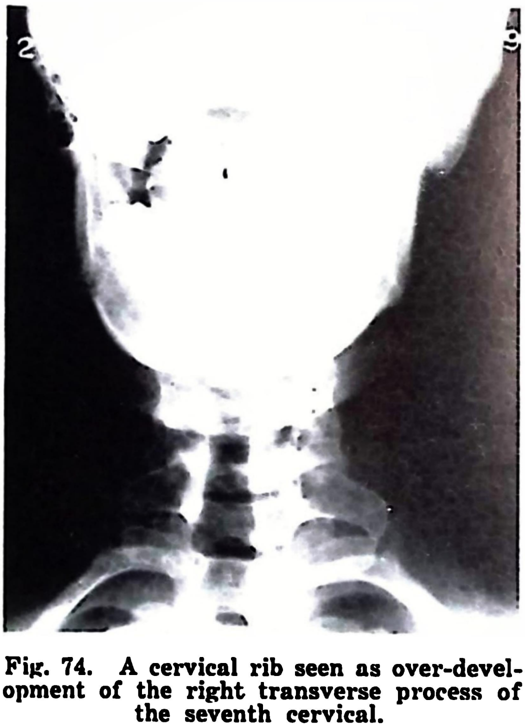


Fig. 74. A cervical rib seen as over-development of the right transverse process of the seventh cervical.

odontoid lock between it and the atlas anterior arch should be kept in mind.

8. Cervical Ribs

A cervical rib is an embryonic over-development of the transverse process of the seventh cervical vertebra. Actually the normal costal process, which should normally fuse with the true transverse process, continues to lengthen and may extend laterally for a distance of two or three inches. Most such ribs however, tend to curve downward and fuse with the first or second true ribs below. Occasionally, a cervical rib will extend upward into the neck and produce extensive adhesions with adjacent nerves, vessels, and viscera to the extent of yielding diffuse symptoms.

Cervical ribs are of particular clinical importance to the Chiropractor because of the frequent painful neuralgia associated with many of these anomalous structures. The Chiropractic prognosis on neuritis of the arm is excellent, and results can be expected in a reasonably short length of time. However, if a cervical rib has been overlooked in routine X-rays of the patient, the continuation of the symptoms may be perplexing.

Due to compression of nerve roots and blood vessels between the cervical rib and the scalenus anticus muscle, a number of symptoms may follow. This group of possible symptoms is known as the **Scalenus Anticus Syndrome.** Due to pressure on the nerve roots of the brachial plexus, there may be severe pain, numbness, and tingling extending down the arm into the hand. The small muscles of the hand may atrophy.

Vascular obstruction, such as pallor of the hand and fore arm, with lowered temperature of these parts, may be noticed. When the arm is elevated above the head, color changes in the hand may be demonstrated.

Frequently the first indication of a cervical rib is a pulsating tumor above the clavicle and lying deep in the neck. The partially compressed subclavian artery gives the tumor its pulsating quality. Cervical ribs are bilateral in most instances, and they seem to occur somewhat more frequently in women than in men. Since it is a congenital condition, it may be noted in early childhood.

Lumbar ribs are infrequently observed. They generally produce no symptoms. Attachment is to the first lumbar vertebra, and the

anomaly is almost always bilateral. Most lumbar ribs appear as short lateral growths, one to two inches long, located slightly above the transverse process of the first lumbar vertebra.

9. Cervical Spondylolisthesis

This may be defined as an anterior displacement of the body of a cervical vertebra in relation to the vertebra above or below. Seemingly, this condition affects the lower cervical vertebrae more often than it does those of the upper cervical group.

The possibility of a cervical spondylolisthesis should not be overlooked in making a Chiropractic analysis of this area, particularly when a cervical lordosis is observed. The anterior displacement of the vertebra with subsequent strain and distortion of the cervical ligaments and musculature may present symptoms ranging from those of local pain and tenderness, to evidence of spinal cord pressure. Chiropractic X-rays of a lateral cervical view will generally show the displacement. In addition, there may be ankylotic formations on the articulating surfaces of the vertebrae concerned, as well as some malformation and unusual angles of inclination of these processes.

B. MALFORMATIONS OF THE THORACIC REGION

The vertebrae of the thoracic region seem to be less frequently involved in malformations than do those of the other regions of the spinal column. Just why this should be so is difficult to explain, but Chiropractic experience has found most cases of thoracic vertebral anomalies to be confined to a single vertebra, and such malformations as do occur are apt to be less distorted than in other regions. A common deviation from normal, however, is found in the varying number of thoracic vertebrae; thirteen dorsals is not unusual, and only eleven dorsals have been observed in a few instances. The former condition is one of developmental excess, and the latter results from developmental failure. It has been estimated that as high as 20% of all spinal columns show numerical variations of one sort or another. Congenital absence of a transverse process, spinous process, or other descriptive part is seen rather frequently in the thoracic region, and no clinical symptoms may be present. However, there are two malformations of the vertebral bodies in this region which merit brief mention because of their contributions to spinal curvatures.

1. **Wedged Vertebrae**—are rarely seen as a true congenital condition, but when present, the condition is obvious upon X-ray examination. In wedged vertebrae, only a single half of a vertebral body is present, the other half having failed to develop. In time the weight of the trunk will tend to shape the vertebral body into a triangular wedge, with the apex directed medially, and a scoliosis will appear oftentimes, accompanied by ankylosis around the involved spinal segment.

2. **Butterfly Vertebrae**—this condition is another one which is more or less confined to the thoracic vertebrae. Here, both lateral halves of a vertebral body have formed but have not united in the median line. The two halves are frequently wedge-shaped, and with their corresponding transverse processes, are rather similar in appearance to a butterfly with wings outspread. Frequently there is inequality of size of the two separate parts, and the result is a spinal curvature, particularly a scoliosis or kyphosis.

C. MALFORMATION OF THE LUMBAR REGION

The lumbar region is undoubtedly the most frequent site of congenital spinal anomalies, and probably more of these are discovered through spinal analysis than in other spinal areas because of the frequent complaints referable to the lower back. Also, the heavy strain of weight bearing, and the relative freedom of motion may account for the frequency of symptoms arising from a lumbar vertebral anomaly. The more common congenital abnormalities include spondylolisthesis, sacralization of the transverse processes, and spina bifida.

1. Spondylolisthesis

Spondylolisthesis is defined as the forward displacement of one vertebra over another. The great majority, about 80%, involve the 5th lumbar body over the body of the sacrum, and in about 12% of all cases, the body of the 4th lumbar is displaced in relation to that of the 5th lumbar. Unless otherwise specified, it is assumed that the vertebra concerned has been displaced anteriorly in relation to the one below it. However, posterior displacement is also possible, and the condition is still technically one of spondylolisthesis. Authorities are not in agreement as to whether or not this can be considered a congenital condition, and whether deformities of the neural arch of the involved vertebra are always present.

Fig. 75. True Spondylolisthesis as seen in lateral view of lumbars. The body of the fifth lumbar as well as its pedicles and superior articular processes have slipped forward in relation to the sacrum. Note that the other lumbars are also somewhat displaced anteriorly.

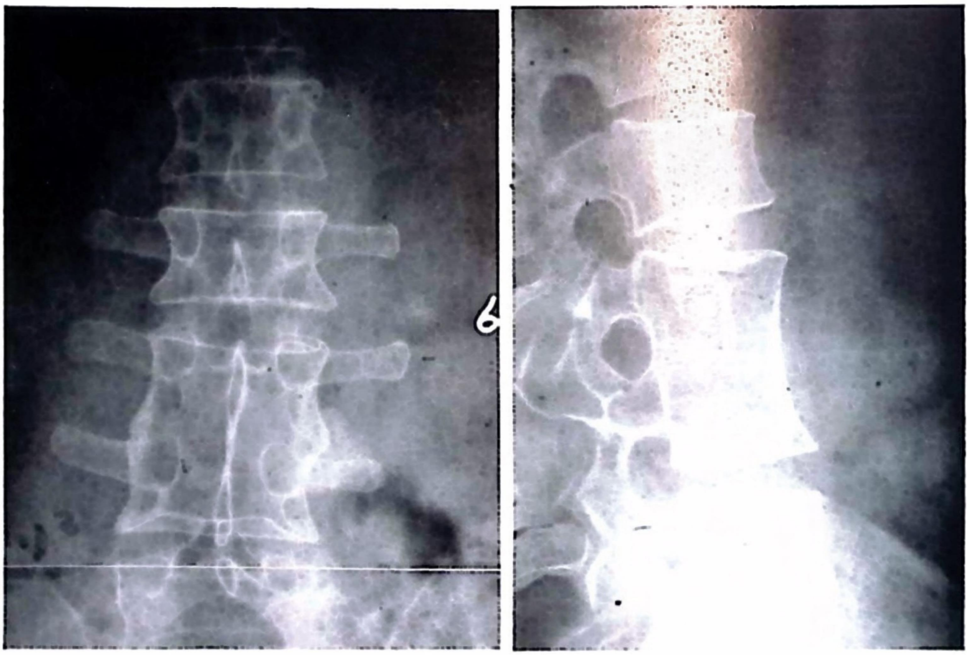


Fig. 76. A. to P. and lateral lumbar views showing block vertebrae. There is partial fusion of the third and fourth lumbars.

The usual Chiropractic understanding of the term spondylolisthesis may be summed up as follows: "An anterior displacement of the 4th or 5th lumbar vertebra, usually congenital, and almost always accompanied by defects of fusion of the neural arch of the involved vertebra."

It is quite possible that many cases considered as congenital may actually be the result of an injury to this area of the spinal column, either during intra-uterine life, or the early years, and such trauma has interfered with the normal development of the neural arch as well as with the relation of the vertebra with the one above, the one below, or both. Detection of spondylolisthesis is based upon careful study of lumbar x-ray films, particularly those taken lateral to the lumbar spine. Physical examination may show a shallow dimple over the lower lumbar region, due to depression of the spinous process of the 4th or 5th lumbar vertebra. The clinical picture described with spondylolisthesis is primarily one of low back pain appearing usually between the ages of 30 to 40 years. The pain is local, being referred to the lumbosacral region, and is not sciatic in its distribution. Frequently, the attacks of pain develop after trauma to this region. Perhaps the outstanding complaint of the patient is one of a "weak back" because bending or lifting, or similar physical exertion, will bring on an attack of pain.

Very likely much of the discomfort arising from spondylolisthesis is due to excessive tension of the local supporting ligaments and muscles. The anterior displacement will, of necessity, strain the spinal ligaments, and the possible absence of proper points of attachment for the involved muscles may combine to produce a continuous distortion which cannot cope with any undue extra strain. Then too, a lumbar lordosis with its attendant strain may result from the displacement.

In some few cases the condition of spondylolisthesis will be discovered only during routine Chiropractic analysis of this region of the spinal column; no symptoms will have ever appeared at any time.

2. Pseudospondylolisthesis

This term is applied to an anterior displacement of the fourth or fifth lumbar vertebra without any evidence of defect in the neural arches. There is usually a weakening of the intervertebral disc which permits the vertebral body to project forward beyond

its normal relationship with the adjacent vertebrae. Frequently there is an accompanying ankylosis of the articular surfaces, and these surfaces may show an abnormal angle of inclination thus permitting unusual freedom of motion which very likely accounts for the ankylotic changes created to limit this undue motion.

Pseudospondylolisthesis may account for low back pains and similar symptoms as found in true spondylolisthesis; the difference between the two being essentially the malformation of the neural arch in the one, and the normal arch in the other.

3. Reverse Spondylolisthesis—is a condition in which the body of a lumbar vertebra shows a posterior displacement rather than the usual anterior displacement found in a true spondylolisthesis. Most cases involve the fifth lumbar which moves posterior to its normal relationship to the sacrum. There is no deformity of the neural arch, but the lumbosacral intervertebral disc is generally narrowed and weakened. Evidently the loss of strength of the local spinal ligaments plus the abnormal shapes of the articular surfaces permit the backward displacement of the lumbar vertebra on the sacrum. If posterior displacement is great enough, there may be a compression of nerve roots of the cauda equina producing symptoms of sciatica, backache, and other local conditions.

4. Block Vertebrae

This condition involves principally the lumbar vertebrae, and may be considered as a congenital synostosis, the lumbar counterpart of the cervical "Klippel-Feil Syndrome." There is partial or complete fusion of two or more lumbar vertebral bodies, so that the structures appear somewhat as an oblong block of bone tissue rather than the typical square shape of a lumbar body.

Block vertebrae result from embryonic maldevelopment in which adjacent sclerotomes fail to separate, but instead fuse into a single solid mass. In fact, not only the vertebral bodies but their other descriptive parts are also fused and distorted. The spinal nerves which should emit through the absent intervertebral foramina are usually detoured into the patent foramina above or below the lesion.

Block vertebrae frequently contribute to a spinal curvature, particularly a kyphosis, due to overdevelopment of the posterior half of the deformity, and undervelopment of the anterior half which causes an angulation toward the posterior.

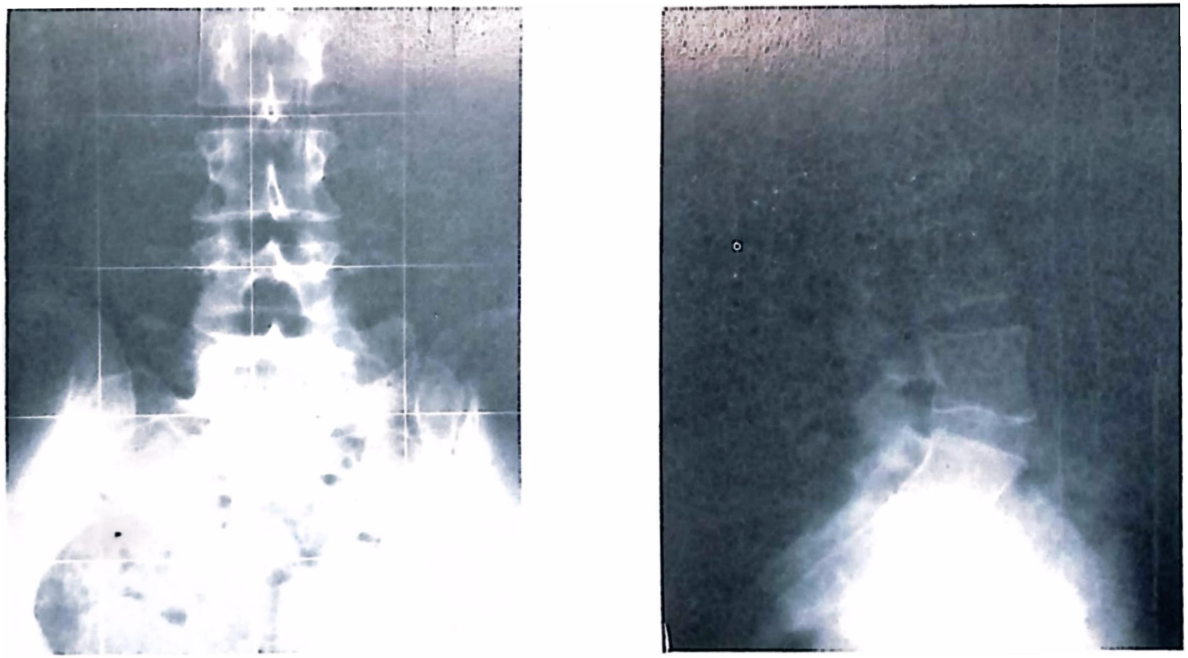


Fig. 77. Sacralization—the A. to P. view shows the unusually large transverse processes of the 5th lumbar; the lateral view illustrates the blending of the 5th lumbar body into the sacrum base.

5. Sacralization

The term sacralization signifies an exaggerated development of the transverse processes of the fifth lumbar vertebra until they appear like parts of the sacrum. The condition is an embryonic malformation and represents a transitional development in which the unusually large transverse processes, and the inferior surface of the fifth lumbar vertebra, are frequently fused to the first sacral segment.

Not all cases of sacralization will present symptoms referable to the lower back, but when such symptoms are present they closely resemble those of spondylolisthesis; namely, pain, tenderness, and complaint of a "weak back." The condition is easily detected by Chiropractic X-ray.

In some instances, the first sacral segment is completely detached from the rest of the sacrum, and is referred to as a "Lumbarized Sacral Segment." This is much more rare than sacralization which is rather a common lumbar anomaly.

6. Pilonidal Sinus and Pilonidal Cyst

A pilonidal cyst or pilonidal sinus is a sac-like structure, usually containing hair and located in the sacro-coccygeal region of the spinal column. It often opens at a post-anal dimple by way of a pilonidal fistula. The tendency towards a pilonidal sinus is considered as congenital, and it represents a failure of atrophy of an embryonic saccular termination of the neural tube in the overlying skin. This structure constitutes the coccygeal vestige, and is frequently marked on the skin by a pit or dimple in the skin. In some few cases the filum terminale is converted into a tubular structure, connecting directly with the central canal of the cord. The typical pilonidal sinus is a congenital lesion which makes its appearance at about the ages of fifteen to thirty, and is more common in males. Most sinuses appear as a small depression over the sacrococcygeal joint, and have a minute opening directly in the mid-line of the gluteal cleft, well above the anal opening. In some instances no opening can be found but a small cyst can be seen and palpated. Frequently, a small bunch of hair will be seen protruding from the opening. The clinical symptoms of a pilonidal sinus follow a rather definite pattern. The first indication may be a slight oozing of serous-like fluid which gradually increases in quantity to the point that it wets the underclothing. The patient now may notice tenderness in the sacro-coccygeal area, particu-

larly upon sitting, and frequently attacks of severe pain are experienced. The discharge is oftentimes intermittent rather than constant, and for some weeks or months may be entirely absent.

Infection may involve the sinus with the formation of a painful abscess which discharges a thick purulent matter through the fistula. Pilonidal sinus is sometimes referred to as "jeep spine" because of the unusual increase in discovered cases during World War II in which many military personnel were subjected to the jarring and jolting of military transport.

Chiropractic care has shown good results with many cases of pilonidal cyst, but in those few which are not amenable to Chiropractic adjustments, the cyst may have to be removed surgically. Such an operation is frequently extensive due to adhesions and the proximity of many nerve fibers, so it should be performed only by one well-trained along such lines. Although the majority of pilonidal cysts are found in the sacro-coccygeal region, the condition occasionally appears in the thoracic and cervical regions where it frequently accompanies a condition of spina bifida.

D. CONGENITAL MALFORMATIONS AFFECTING ANY OF THE SPINAL REGIONS

1. Spina Bifida Occulta

Spina bifida occulta may be defined as a congenital cleft of the vertebral arches without protrusion of the spinal cord and its meninges. The condition is characterized by absence of the spinous process and failure of fusion of the laminae in the midline. It frequently shows a patch of hair over the affected vertebra which in most cases will prove to be the fifth lumbar vertebra or first three sacral segments. It is one of the most common congenital spinal defects, and in many cases, will produce no symptoms whatever, but rather is detected in routine Chiropractic X-rays of the spinal column. However, if spina bifida occulta is to give trouble it usually does so about middle age. One condition frequently associated with it is an extensive growth of fibrous and fatty tissue within the neural canal which may produce indications of pressure upon the spinal cord or spinal nerves of the affected region. The defect is due to incomplete closure of the two halves of the primoidial vertebra resulting in a lack of fusion of the laminae to form a proper spinous process.

2. **Spina Bifida**

True spina bifida is much more severe than spina bifida occulta, and because of the protrusion of the cord and meninges from the cleft in the vertebrae, the condition is clearly evident. It is also termed **Rachischisis** and **Schistorachis**, although in its strict sense, rachischisis implies a more advanced form of spina bifida with absence of pedicles and laminae and direct exposure of nervous tissue. When there is herniation of the spinal cord and its meninges, there appears a bulging, fluctuating tumorous mass, but when Innate has adapted to the condition, there may be a shallow pocket-like scar over the site. This scar represents the pull of adhesions attached to the adjacent laminae.

Spina bifida may occur at any level of the spinal column, but is most often seen in the sacral and lower lumbar segments. About 50% of all cases involve the lumbar vertebrae, 12% in lumbrosacral region, and 27% sacral. It is not uncommon in the Atlas and Axis region.

The most extreme and most rarely seen form of spinal bifida is called **rachischisis**. In this condition, a large section or all of the vertebral column may split with protrusion of the entire spinal cord. The outstanding symptom of spina bifida, aside from the spinous defect, is the tumorous protrusion. This varies in size from that of a walnut, to an orange, to the size of a child's head. Sometimes, the soft, mobile mass is covered with skin of normal color, but more often the skin is thin and translucent, or the skin may be entirely absent in which case the lumbar area has a red, raw appearance. The soft texture of the tumor is usually credited to an accumulation of cerebrospinal fluid within the distorted and compressed sub-arachnoid space. Frequently, pressure upon the tumor will induce a loss of consciousness due to increased intra-cranial pressure.

Different terms are applied to the types of tumors based upon the structures involved; fundamentally, three types are recognized.

(a) **Meningocele** — is also known as spinal meningocele when accompanying spina bifida. It denotes protrusion of the meninges through a cleft in the neural arch.

(b) **Meningomyelocele** — indicates a herniated protrusion of a part of the spinal cord and its meninges.

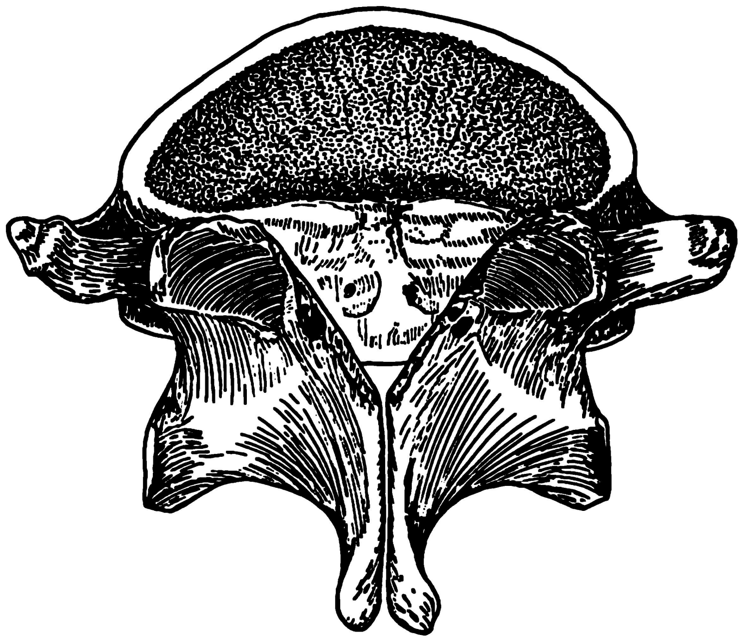


Fig. 78. Spina Bifida occulta of fifth lumbar vertebra.

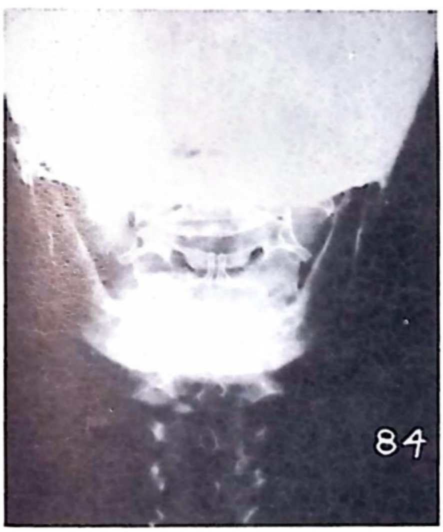


Fig. 79. Spina bifida occulta of axis.

Fig. 80. Spina bifida occulta of sacrum.

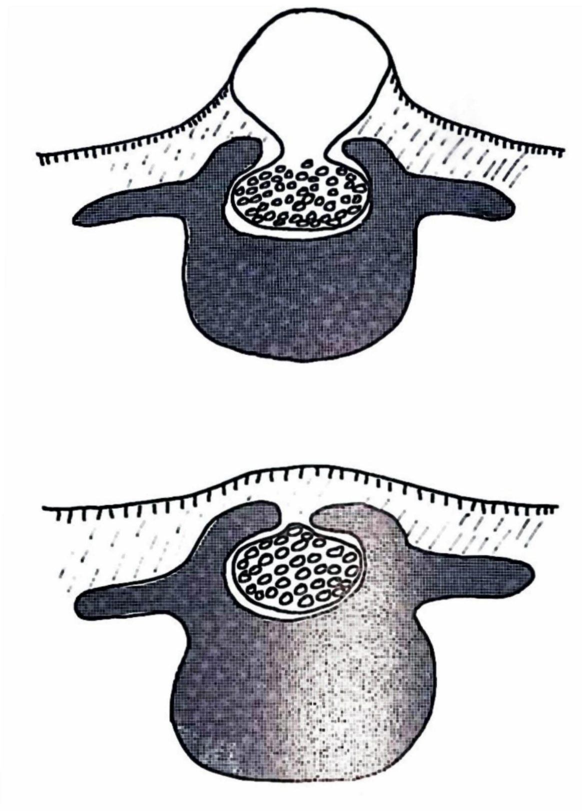


Fig. 81. Two examples of spina bifida—in the upper drawing the meninges are protruding to form a meningocele. In the lower drawing only the neural arch is deficient and the meninges are located normally — spina bifida occulta.

Fig. 82. A. to P. view of lumbar region showing extensive true spina bifida of the lower lumbars. This case had a meningomyelocele.

(c) **Syringo-Myelocele**—this condition exists in spina bifida when the central canal of the spinal cord is dilated and forms the cavity of the protruding structure. The cavity is filled with cerebro-spinal fluid and is formed by a twist or kink in the central canal when it passes outward with the spinal cord into the cleft.

In all three forms, there are certain recognizable features present which follow a rather consistent pattern.

1. The tumor is congenital.

2. It can usually be reduced slightly by applying pressure, and such reduction may produce symptoms of intra-cranial pressure such as stupor, vomiting, or convulsions. Pressure on the tumor may also cause the fontanelles to bulge.

3. The tumor is located in the median line of the spinal column.

4. The tumor becomes more tense when the child coughs or cries or otherwise strains.

5. There is frequently a profuse growth of hair over the involved vertebral arches.

6. Palpation reveals the absence of a spinous process.

7. If the tumor is covered by a thin translucent skin, it is possible to see the spinal cord beneath the skin.

8. Proper X-rays will show the failure of the vertebral arches—spina bifida.

The symptomatology of spina bifida shows a wide variation as the symptoms will depend upon the location, extent, and severity of the condition. Definite symptoms attributable to the condition usually indicate pressure upon the spinal cord and nerves.

There may be hyperesthesia or anesthesia. Incontinence of the urine is a common symptom. Either flaccid or spastic paralysis of the lower extremities may develop and a common occurrence is the appearance of clubbed feet due to spinal cord pressure. Vasomotor disturbances are common, and frequently the mentality is impaired from intra-cranial pressure.

The usual course of cases of severe spina bifida is toward death which commonly occurs within six to eight months. Oftentimes perforating ulcers appear in the skin and membranes over the involved area, and the contents of the sac escape, which is followed soon by convulsions and death. Infection of the ulcerated area is also a possibility.

A milder form of spina bifida may contribute to the formation of spinal curvatures, particularly a scoliosis, because in many cases, not only is the arch malformed, but the vertebral body as well, which makes for imbalance of the entire spinal column.

Cervical Meningocele or Cervical Myelomeningocele is a globular, tense, smooth compressible tumor, situated in the midline beneath the occiput. It is present at birth and increases in size with crying or straining. Upon being compressed a slowing of the pulse rate and vomiting may be produced. X-ray examination will usually show a congenital defect in the occiput above the foramen magnum, or a cleft posterior arch of Atlas or both. Its clinical course is similar to that observed in such tumors located elsewhere in the spinal column.

3. Arnold-Chiari Malformation

The Arnold-Chiari malformation is a condition in which the medulla oblongata and part of the cerebellum are deformed to the extent that they project downward through the foramen magnum into the atlanto-axial neural canal. The malformation exists in varying degrees of severity, but in most cases the prolapsed portions of the brain will compress the upper part of the spinal cord as they are both contained in the upper cervical neural canal.

The Arnold-Chiari malformation is considered a congenital defect in which hydrocephalus, or other intra-cranial pressures, have forced the lower part of the brain out of the skull to encroach upon the neural canal. The resulting pressure interferes with proper formation and closure of the bony vertebrae and the foramen magnum to the extent that spina bifida or other fusion defects usually accompany the malformation.

Another possible reason for the malformation may be the pull of adhesions surrounding the lower spinal cord at the site of a meningocele. The traction thus created may pull the brain downward because, after the third embryonic month the spinal

column grows progressively longer than the spinal cord. In the majority of cases, the Arnold-Chiari malformation is accompanied by other severe distortions of the cervical region, such as Klippel-Feil syndrome, platybasia, and cleft posterior arch of atlas. Obviously, a great variety of symptoms may be produced by this congenital malformation. Pain in the upper cervical region may result from nerve root compression. Hydrocephalus symptoms develop from interference with the flow of cerebrospinal fluid. Loss of equilibrium, vomiting, and visual disturbances may accompany pressure upon the cerebellum. A generalized motor and sensory paralysis may be present and in some cases the clinical picture is very similar to that of multiple sclerosis.

Any case undergoing a Chiropractic analysis which shows gross malformation of the cervical vertebrae, or of the occiput, should be regarded with suspicion as to the Arnold-Chiari malformation; particularly so if nerve pressure is detected and still exists after a reasonable length of time under Chiropractic care.

4. Hemivertebrae

This congenital condition is a vertebral defect in which one or more of the vertebrae are incomplete due to developmental failure. It may occur in the lumbar, dorsal, or cervical portion of the spine. When it occurs in the dorsal portion, it is often associated with congenital absence of the ribs normally attaching to the involved vertebrae, or there may be fusion of several ribs on one side and absence of the corresponding ribs on the opposite side.

Since most hemivertebrae are wedge-shaped and are developed between normal vertebrae, they almost invariably cause spinal curvature by disturbing the balance of the spinal column. Hemivertebrae is a common cause for congenital scoliosis.

5. Diastematomyelia

Literally, this term means a fissure in the marrow, and the definition of diastematomyelia or diasto-myelia is a congenital separation of the lateral halves of the spinal cord. The condition is relatively infrequent, but is of importance because of the definite bony abnormalities which accompany it; spina bifida, meningocele, and myelomeningocele are other attendant anomalies.

The spinal column frequently gives a clue to the abnormal cord by presenting such abnormal formations as hemivertebrae, kyphosis, scoliosis, absent neural arches and spina bifida. Usually only a part of the spinal cord is abnormally cleft with the cauda equina and lumbo-dorsal regions being most frequently affected.

Symptoms of nerve interference are frequently present. The most common of these include muscular and bone maldevelopment of the lower extremities, failure to walk properly as the child grows, and loss of control of bladder and rectal sphincters.

Diastematomyelia is probably due to a severe embryonic disturbance in which an attempt to form a twin was interrupted very early in the formative period, and the development continued from this point with resulting bone and spinal cord anomalies.

Chapter 10

INFLAMMATORY DISEASES OF THE SPINE

(Non-Infectious)

1. Marie-Strumpell Disease. (Ankylosing Spondylarthritis, Rheumatoid Arthritis)

This is a fairly common inflammation and ankylosis of the joints of the spinal column, costo-vertebral articulations, and later the hips, knees, and other joints. The disease usually appears between the ages of 20 and 40, more often in females, and in male athletes and laborers.

Most cases of ankylosing spondylarthritis develop slowly over a period of several years, although they may follow an acute course. Remissions and exacerbations are not infrequent. It generally begins with low back pain in the lumbo-sacral region, and x-ray films at this time will usually disclose a cloudiness of the sacro-iliac articulations. Sciatic pain frequently develops along with the low back pain.

The early pathological changes in the spinal joints include a marked proliferation of the articular capsules, synovial membranes, and surrounding soft tissues. Granulation tissue next replaces the articular cartilages. The marrow cavities next to the articular cartilages are also inflammed and granulation tissue extends throughout these cavities. Finally, the extensive areas of granulation tissue replace virtually all of the normal joint tissues resulting in marked deformity of the joints and ankylosis with loss of function.

The typical case of Marie-Strumpell disease will show a definite sequence of events upon spinographic examination at spaced intervals. First, will be observed the cloudiness in the sacro-iliac joints; second, bony bridges, or spurs will form

Fig. 83. Ankylosing spondylarthritis—sometimes known as "rheumatoid spine." There is a characteristic fluffiness with loss of definite outline of the vertebral bodies.

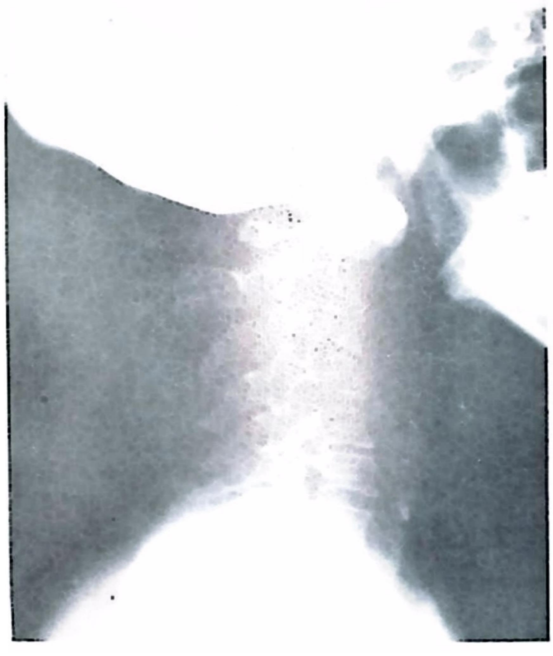


Fig. 84. Cervical ankylosing spondylarthritis—Chiropractic findings show a frequent tendency towards extreme anteriority of the Atlas—very obvious in this view—and probably due to ossification of the local tissues.

across the articular surfaces; and third, complete fusion and ankylosis may be noted. The intervertebral disc is generally involved in the disease to the extent that it frequently shows a marked narrowing in the involved region, particularly in the thoracic area. Later on the intervertebral spaces may be invisible. Marie-Strumpell's disease is almost always progressive. Beginning in the sacro-iliac and lumbar regions, it gradually ascends to involve the thoracic and cervical regions, each of which shows the usual joint pathology and paravertebral calcification. The patient complains of a great deal of pain along the spinal region, and motion is decreased, both as the result of joint destruction and protection against pain. Finally, motion is virtually absent because of the ankylosis of most of the spinal column. The spine loses its lumbar lordotic curve and the dorsal curve is exaggerated, and the entire region becomes a fixed, fused mass so that the common term applied to the later stages of ankylosing spondylarthritis is "poker spine."

In most cases, there is an accompanying ankylosing of the costo-vertebral joints which greatly interferes with chest expansion. Gradually the spine distortion and ankylosis tends to pull the entire trunk forward so that the patient usually walks with the trunk nearer the horizontal than the vertical plane and with the head jutting forward.

2. Still's Disease (Juvenile Rheumatoid Arthritis)

This form of rheumatoid arthritis occurs in children aged two to five years. The joints most commonly affected are those of the hands and feet, wrists, knees, and ankles. When it involves the spinal column, it pursues the same clinical course as adult ankylosing spondylarthritis; in fact it seems to be merely the juvenile form of this disease and is relatively uncommon.

3. Bechterew's Disease (Spondylosis, Hypertrophic Arthritis)

This disease is also known as osteoarthritis, senile arthritis, hypertrophic arthritis, and degenerative arthritis. For all practical purposes it might be considered a spinal disease closely paralleling the clinical appearance of ankylosing spondylarthritis without the pain common to the latter condition. In general it is a chronic degenerative form of arthritis occurring mostly in people past the age of forty, and producing hypertrophic changes of the bone, cartilage, and synovial membrane. Most of the time it is without symptoms unless the developing spurs

of bone create pressure upon the spinal cord or nerve roots. The primary change takes place in the intervertebral discs, which because of advancing age lose their elasticity and shape, becoming more flattened. The adjacent periosteum tends to become overactive in the formation of osteophytes which form bridges or spurs of bone tissue between adjoining vertebrae. These exostotic growths tend to protrude in all directions from the vertebral bodies and intervertebral discs, and may invade the spinal canal or intervertebral foramina to compress the cord or nerve roots. Involvement of the cervical vertebrae is most frequent, followed by the thoracic and lumbar vertebral regions; the sacroiliac areas are not commonly involved in hypertrophic arthritis in contrast to rheumatoid arthritis which generally appears first in this region.

Not only are the characteristic spurs formed in the vertebral bodies, but they may also appear on the articular facets of the spine. However, there is little if any true ankylosis, and the patient is only slightly crippled as regards spinal movement. The usual signs of inflammation are not associated with the disease, but rather, it is an insidious degeneration of bone and cartilage, with resulting moderate deformity, so that the term spondylosis deformans is well taken.

It is said that spondylosis may develop more frequently in those individuals whose occupations require heavy lifting or excessive bending and strain, such as stevedores or other laborers.

TABLE OF COMPARISON OF SPINAL RHEUMATOID ARTHRITIS AND SPINAL OSTEOARTHRITIS

Rheumatoid Arthritis Acute	Osteoarthritis Chronic
An inflammatory condition of vertebral joint tissues.	A degenerative condition of cartilage and bone of spinal column.
Fibrous adhesions formed in the joint tissues. Effusion into the joint is common.	Involvement of the bone and periosteum produces exostoses. Effusion into the joint is rare.
Ankylosis produces rigidity of the spinal column.	Exostosis produces rigidity to a lesser degree.

Toxic symptoms include fever, loss of weight, anemia, and generally debility.	No definite toxic symptoms.
Local signs of inflammation, swelling, atrophy of muscles, extreme pain, marked deformity.	No local signs of inflammation, deformity is moderate. Pain is usually absent.
Generally occurs in people under forty years of age. More common in females.	Generally, occurs in people over forty years of age. More common in males.
History of injury or disease.	No previous history of injury or disease.

4. Interspinal Osteoarthrosis

This rather unusual inflammatory condition of the spine results from contact between the tips of the vertebral spinous processes. It may follow an increase in the anterior curve of the lumbar spine or various spinal conditions in which the vertebral bodies shrink in size and allow the adjacent spinouses to contact one another. This results in injury to the interspinous tissues and painful changes suggestive of arthritis may follow. The pain is usually aggravated by spinal movement such as rotation, flexion, and extension. Spinographs will show the spinous tips in contact with each other, and there may be exostotic or ankylotic changes in the involved area. Because of the approximation of the spinous processes, this form of spinal arthrosis is sometimes called "kissing spine."

CHIROPRACTIC AND INFECTIOUS DISEASES OF THE SPINE

The following diseases are commonly accepted as being associated with certain bacteria, fungi, or parasites. Chiropractic does not, and never has denied the existence of bacteria or parasites. However, Chiropractic has always steadfastly maintained that a normal, healthy body is able to withstand the invasive forces represented by the agents of infection or parasitism. This viewpoint has been upheld many times over by the findings of immunologists, although not expressed in so many words. Bacteria and other infectious agents can poison a body of lowered re-

sistance by their secretions of powerful toxins, corrosive chemicals, or other deleterious metabolic products. This can be done only when the limits of resistance or adaptability of the invaded body has been reached, and a state of disease may ensue. A body free of nerve interference, with attendant normal function of all tissue cells, is able to successfully cope with this invasive force, and even though exposed continuously to the organisms no disease ever develops. Pott's disease and syphilis of the spine are secondary reactions following an initial lowering of body resistance and adaptability to the associated bacteria.

It is interesting to note that the described parasitic diseases of the body, including the spinal column, are characterized by the formation of cysts to enclose the parasites. It has long been understood that cysts due to foreign bodies are an effort on the part of nature to encapsulate these alien substances. Parasitic cysts are included in this category. Thus if the infectious material is able to thrive and multiply and throw off destructive products, the tissue changes in the pathological picture may be attributed to their presence; but in turn, their presence is due to the incapability of the body to withstand their invasive power—a matter of interference with nerve impulse transmission.

INFLAMMATORY DISEASES OF THE SPINE

(Bacterial Infections of the Spine)

1. Tuberculosis of the Spine (Pott's Disease)

This disease is considered a tuberculous form of osteomyelitis, and is variously referred to as angular curvature, caries of the spine, and tuberculous spondylitis. Tuberculosis of the bones is most common in childhood. It usually begins in the cancellous tissue of the vertebrae, or in ends of long bones, particularly the femur and tibia. The disease is primarily an osteomyelitis, and is most likely to appear in those cases with a history of impaired health, poor hygienic surroundings, and injuries which are seemingly often slight in nature.

Pott's disease is essentially a disease of childhood, but may occur in adults. In children the disease most frequently attacks the upper thoracic vertebrae, whereas in the adult, the vertebrae most often involved are the last three thoracic and first two lumbar. As a rule two or more vertebrae are involved. In children the

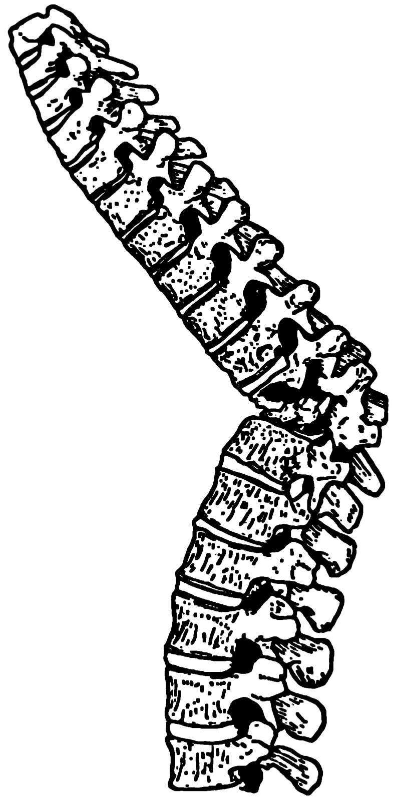


Fig. 85. Angular curvature resulting from spinal tuberculosis.

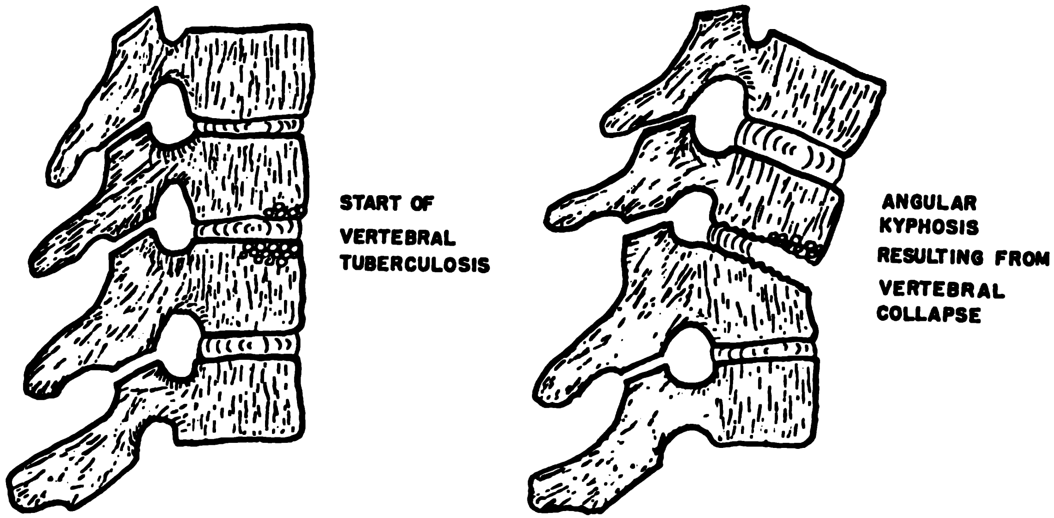


Fig. 86. Tuberculosis of the spine. The disease starts near the anterior of the vertebral bodies and destroys the disc which in turn causes vertebral collapse and angular kyphosis.

disease attacks the centers of the vertebral bodies, and in adults the periphery of the bodies is the site of the primary attack. When the central portion is involved the bone is destroyed and replaced by granulation tissue which becomes converted into a softened caseous material. Eventually, the vertebral bodies are crushed by the weight they are supporting, and this collapse brings about a severe spinal curvature. When the peripheral portion of the vertebra is attacked the deformity is less, due to a smaller amount of bone destruction.

The pathology is the same as that of any tuberculous bone disease elsewhere in the body. At first, one or more tubercles are formed and other tubercles are then formed around them. Small areas tend to become encapsulated, and larger ones form a sequestrum which gradually softens and forms a tuberculous abscess. The cancellous bone of the vertebral body is gradually destroyed and the disease spreads to neighboring vertebrae by passing beneath the anterior longitudinal ligament, or it may spread by way of the intervertebral discs.

Caseous degeneration takes place and pus forms to discharge through pathways offering the least resistance. In some cases, there may be bone destruction without pus formation (caries sicca) and in others there is an area of bone destruction that has become separated from the sound bone during the process of necrosis (caries necrotica).

It is said that the tubercle bacilli invade the vertebrae by way of the blood stream, and as there is a rich blood supply to the upper and lower cartilaginous plates these portions of the vertebrae frequently show the initial tubercular lesions.

Tuberculous pus has a pronounced tendency to burrow through adjacent tissues and approach the surface at a considerable distance from the diseased bone, the point of discharge depending upon the location of the involved vertebrae. Abscesses above the diaphragm tend to remain above the diaphragm. In the cervical region the pus may collect between the vertebral column and the posterior pharyngeal wall, forming a retropharyngeal abscess. In the vertebrae of the thoracic region the pus may enter the sheath of the psoas muscle to form a psoas abscess, or it may discharge lower in the pelvis at the groin, or even into the thigh region. In the lumbar region, the pus may drain posteriorly to the surface to form a lumbar abscess. Lumbar and psoas abscesses have been known to drain as low down as the heel, or to discharge

into the rectum, vagina, and bladder. Lumbar disease is frequently attended with colicky pain, irritation of the bladder, and incontinence of urine. Cervical disease may cause difficulty in swallowing, and torticollis. The intervertebral discs are particularly affected by this pus formation, being rapidly destroyed by its erosive action. Loss of the discs causes adjoining vertebral bodies to collapse against each other.

The vertebral bodies may be affected in two different ways by tuberculosis of the spine. There may be a softening change into a cheesy substance (caseation), or there may be a hardening of the bone (sclerosis). The sclerotic changes are caused by granulation tissue and caseous material filling the marrow cavities rather than any increase in density of the bone itself. It is not uncommon for the same vertebra to show areas of caseation and sclerosis at the same time. Frequently, Chiropractic X-rays of the tubercular spinal column will show a decreased thickness of an intervertebral disc with a hazy, shadowy outline of the adjacent vertebrae. As the disease progresses the disc rapidly shrinks in size and definite evidence of vertebral bone destruction appears. This may take the form of areas of increased density, areas of densely ossified bone within or adjacent to the usual bone structure, and areas of decreased density representing the active tubercular lesion.

As the case begins to show healing progress there is increased density of the bone which previously showed destructive changes. This represents new, healthy bone. Innate further acts in the healing by forming ankylosis of the vertebrae, and organization or calcification of the surrounding inflammatory tissue.

The local symptoms of Pott's disease are pain, spinal weakness, rigidity, deformity, abscess, and paralysis.

Pain is rarely severe, and may even be absent. It is increased by local pressure, movements, and jarring of the spine. When the nerve roots are irritated, the pain is referred to the area supplied by these nerves. Children with vertebral tuberculosis will often cry out in pain during sleep because, in sleep, the protectively contracted spinal muscles relax, and movement causes pressure upon the nerves and resultant pain.

Rigidity is due to muscular spasm in the early stages of Pott's disease. It is Innate's method of protecting the diseased part. Later on the rigidity is due to ankylosis. Spinal movements

are carefully performed by the patient—jumping is avoided, as is stooping whenever possible. The patient stoops by bending at the knees and hips rather than from the spinal column. The movement of turning around is carefully carried out by moving the entire body rather than by rotating the spinal column. In walking, the child moves as if on ice, sliding or shuffling along so as to avoid jarring the spinal region. When sitting, the weight of the body is partially supported by grasping the arms of the chair. The cervical region is held stiffly erect and gives rise to a lordosis or "military neck." In fact the child tends to extend the spine to prevent discomfort, and the entire back appears flattened.

Posterior angular deformity is the typical one, and the more vertebrae involved, the more sharp the angle. The resulting spinal hump or protuberance is referred to as a **gibbus** or **kyphos**.

Compensatory curvatures develop in other areas of the spinal column.

Paralysis may occur in about ten per cent of all cases of Pott's disease. It is always a motor paralysis at first, later affecting sensation. It is rarely sudden in onset, and occurs only in the later stages. In most cases, there is a displacement of bone compressing the spinal cord and nerve roots. Undoubtedly spinal trauma plays an important part in determining the appearance of this serious symptom.

2. Osteomyelitis of the Spine

Osteomyelitis is an inflammation of bone associated with a pyogenic organism. The disease may remain localized or it may spread through the bone tissue into the marrow and periosteum. In its true meaning, osteomyelitis is an inflammation of the bone and marrow. Two types are considered, acute and chronic.

Acute osteomyelitis is associated with such pyogenic organisms as Staphylococcus pyogenes aureus (most common), the streptococcus, pneumococcus, Staphylococcus albus, colon bacillus, and gonococcus. The acute type is often the result of bacteria having been carried to the marrow and cancellous tissue by the blood stream. These organisms may come from infected teeth, tonsils, or other foci of infection, or they may enter by way of puncture wounds, amputations, or compound fractures.

Lumbar punctures have frequently been considered as a contributing factor. Acute osteomyelitis begins most often in the end of a long bone, especially the lower end of the femur or upper end of the tibia. The infection tends to spread throughout the entire marrow cavity until the whole shaft becomes filled with purulent material which gradually invades the remaining bone tissues, including the periosteum. In most cases the epiphyseal cartilage protects the joint against invasion which is in direct contrast to tuberculosis of the spine which usually spreads to the joints.

Chronic Osteomyelitis is characterized by more or less acute recurrent attacks spread over a period of many years. A typical example is the osteomyelitis in which the Bacillus typhosus is found, and which may begin a month after an attack of typhoid fever, or may be developed for as long as two or three years. Typhoid fever, tuberculosis, and syphilis are the most common diseases accompanying the chronic form. Brucellosis, or Malta fever is also considered as a factor in chronic osteomyelitis.

Typhoid spine is a term applied to an osteomyelitis or periostitis of the lumbar vertebrae during convalescence from typhoid fever. There are pain, tenderness, and rigidity of the spinal muscles. Suppuration usually does not occur. The chronic form frequently develops a series of abscesses which appear beneath the periosteum of the involved bone.

Osteomyelitis of the spine follows essentially the same course as observed in any other bone involved with the disease. It occurs during the fifth to fifteenth year in most cases and is considered Staphylococcus aureus in type. The disease attacks the vertebral arches and processes less frequently than it does the vertebral bodies. The lumbar spine is the most commonly involved region, the thoracic region is less commonly involved, and the cervical vertebrae show the lowest rate of incidence.

In the early stages of the disease, the bone tissue shows a small area of rarefaction or decreased density usually found in the upper or lower parts of the involved vertebral body. As the disease progresses the area of rarefaction is seen to increase in size, and the vertebral body may show somewhat of a moth-eaten effect upon analysis of spinographs. Frequently the intervertebral disc shows a definite narrowing as the disease spreads into the disc and destroys it. When the infection has extended completely through the intervertebral disc to the body of the

vertebra above or below, there is a large irregular area of destruction stretching between the involved structures.

Osteomyelitis of the spine shows a rapid regeneration of new bone tissues as the disease is arrested and this frequently takes the form of exostosis and ankylosis. The formation of new bone in this condition is in contrast to tuberculosis of the spine in which bone proliferation is rare.

Several complications may attend osteomyelitis of the spinal column. In the cervical region, the disease may affect the adjacent soft tissues by abscess formation pressing against the pharynx, esophagus, or trachea. Various important vessels and nerves traversing the cervical region may be encroached upon.

In the thoracic region, it is not uncommon to find invasion of the lung tissue or the formation of a mediastinal abscess arising from osteomyelitis of the adjacent vertebrae.

Extension of osteomyelitis into the soft tissues adjacent to the lumbar vertebrae frequently results in a psoas abscess, or in the formation of a fistula draining upon the skin of the lower back.

In any spinal region, the infection may spread to the meninges, the symptoms then being typical of meningitis.

Acute Osteomyelitis of the Spine

The symptoms of acute osteomyelitis of the spine may be summed up as acute pain and tenderness, rigidity of the spinal muscles, and the constitutional symptoms of sepsis. A patient with acute osteomyelitis usually gives a history of acute onset of fever, probably with a chill and great prostration, and pain located over the involved vertebrae. The great majority of these cases have a history of trauma to the spinal area involved and redness and swelling over this spinal region begins about one to two days after the appearance of the constitutional symptoms. Blood examination discloses a definite leukocytosis. The pain becomes intense, and the slightest movement of the affected parts increases the pain. The spinal muscles are rigidly contracted to protect against undue irritation from movement. As the disease progresses it may produce signs of meningeal irritation when the infection extends into the spinal canal. Sometimes, the pain is referred to the hip and leg when the lumbar vertebrae show osteomyelitis.

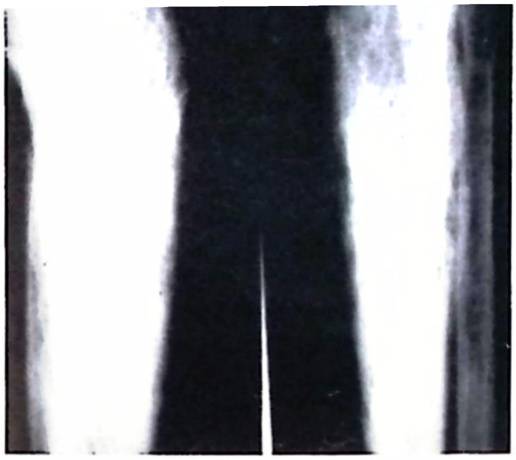


Fig. 87. Osteomyelitis of the tibia: Note the extensive proliferation of bone tissue with areas of rarefaction giving the bone a "moth eaten" effect. Vertebral osteomyelitis shows virtually the same pathology.

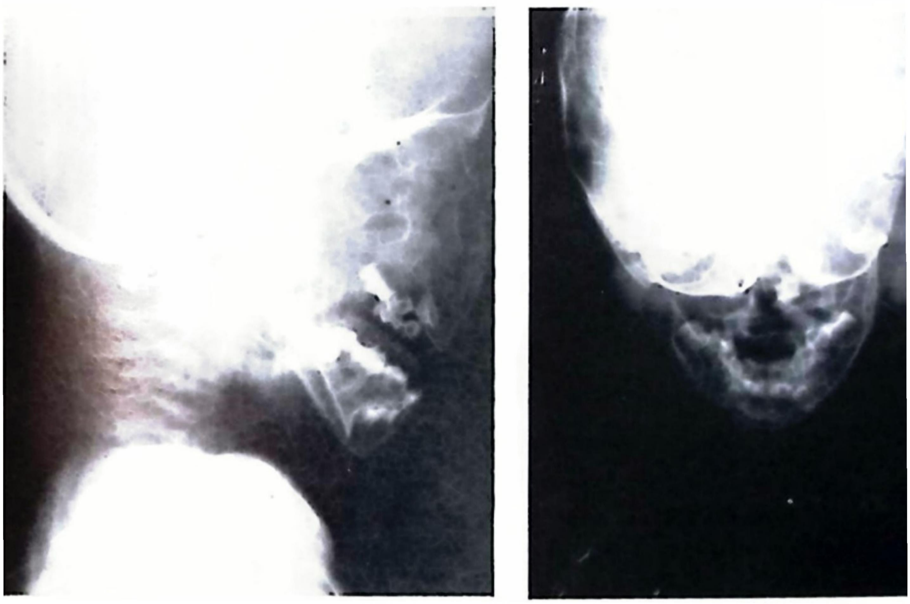


Fig. 88. Congenital Syphilis in child one year old. This is the periosteal type affecting the bones of the face and skull.

Note the worm-eaten appearance bone.

Chronic Osteomyelitis of the Spine

The history of an acute attack with localization of symptoms to the involved vertebrae and the appearance of a soft, fluctuating mass over the spinal region which mass frequently drains by way of a fistula indicates chronic osteomyelitis of the spinal column. Spinal X-rays disclose a thickening of the bone tissue in the involved vertebral bodies along with areas of destruction in the bone and the formation of new bone peripherally, and often the separation of dead bone or sequestra which lie free within the bone of the vertebra. Ankylosis of the vertebrae, as well as infiltration into the surrounding fibrous tissues, is a common finding.

The patient's general condition is frequently poor. There may be loss of appetite, disability of the spinal column, and a persistent low fever. The extent of the spinal reactions and general debility will vary with the number of vertebrae affected, the freedom of drainage, and the recuperative powers of the individual. Chronic osteomyelitis of the spine gives a more severe reaction than does osteomyelitis in most other body areas.

3. Syphilis of the Spine

The spinal column may be affected by either congenital syphilis or acquired syphilis.

In the congenital form destructive changes take place, particularly in the regions of the epiphyseal plates with the granulation tissue replacing bone. Osteoporosis and thickening of the periosteum are other pathological changes noticed in the diseased vertebrae. The vertebrae are not as commonly involved in syphilitic bone changes as are the tibia, sternum, and the bones of the skull.

Vertebral syphilis developing in later life shows a periostitis and generalized bone destruction with extension into the adjacent soft tissues. Obstruction of the blood vessels by the action of syphilis upon the arteries also contributes to bone destruction. The intervertebral discs rarely show any abnormal changes.

Syphilitic spondylitis seems to attack the cervical vertebrae most frequently, the lumbar vertebrae less often, and the thoracic vertebrae infrequently. Perhaps the outstanding feature of vertebral syphilis is the tendency toward an overproduction of bone during the healing process. The production of exostoses and calcification of the paraspinal ligaments is unusually heavy so that

ankylosis is the usual sequel to a healed syphilitic lesion of the spine.

However, the X-ray findings of syphilis of the spine so closely parallel the appearance of other bone pathologies that the only true approach to determining the nature of the disease is through clinical and serological findings. One thing that is of interest chiropractically, is the pseudoparalysis often observed in congenital syphilis of the bone. This is not a muscular paralysis, but rather, is due to weakening of the bone and incoordination of the surrounding ligaments and muscles from the osteitis, periostitis, and osteochondritis.

Syphilis of the bone follows a rather definite pattern, and is more prone to appear in the congenital type than in that which is acquired. Clinically osseous syphilis may be divided into two forms, periostial and endostial.

(a) **Periostial syphilis** affects the periosteum and the bone channels of communication with the Haversian system. There is erosion of these channels which enlarges them and gives a worm-eaten appearance to the bone. The osteoblasts are overactive, with the result that bony proliferation is excessive, the bone becoming thick and dense with elevation of the periosteum. Later, there is an obliterating endarteritis which leads to degeneration of the involved mass and the typical syphilitic gumma is formed. The central part undergoes softening and caseation, and the skin over the area may be involved with the formation of a syphilitic ulcer.

(b) **Endostial syphilis** is concerned with the medullary part of the bone, and there is the formation of gummata which are gelatinous and yellowish colored. The peculiar color is due to the fatty or cheesy metamorphosis of the products of inflammation.

Other typical bone changes in syphilitic infection may show the diaphyses and epiphyses of the long bones separated by an unusual band or zone which is of varying breadth, yellow in color, and irregular in shape (Wegner's line).

Boring pain is a frequent symptom of bone syphilis, as is swelling and tenderness. Formation of a heavy layer of bone on the flat bones of the skull is common during infancy.

It is possible to summarize the subject of syphilis of the bone into the following general pathological changes: (1) syphilitic periostitis, which causes thickening of the periosteum; (2)

a hyperplastic form which may produce thickening of the cortex of the bones similar to that seen in Paget's disease; (3) the formation of gummata in the medullary portions of the bones.

Neuropathic Joints (Charcot's Arthropathy)

Charcot's arthropathy resembles osteoarthritis and is the result of injury or disease of the central or peripheral nervous system, producing a trophic disorder of a joint. Until recently the condition was considered as an exclusive accompaniment of syphilis of the central nervous system, particularly in the form of tabes dorsalis. A Charcot joint is usually described as having a loss of joint contour, being markedly swollen and deformed, but without pain, and palpates as a boggy "bag of bones" mass. It is believed that the extensive damage to the joint which occurs is due to trauma and to the loss of protective pain sense. The joints of the lower extremity, particularly the knees, are most frequently affected. Charcot's disease is divided into the early, or atrophic, and the later, or hypertrophic forms, both of which seem to be the result of trauma, erosion, and the presence of relaxed joint tissues and subsequent hypertrophy. Upon slight injury the joint swells rapidly, and in a few hours it may be dislocated or become so freely movable that it can be bent in any direction. Chronic forms of the disease eventually undergo ankylosis.

The Wasserman reaction of both blood and spinal fluid is generally negative, but the other classical signs of neurosyphilis are present, such as the Argyle Robertson pupil, positive Romberg's sign, etc. It is now understood that Charcot's arthropathy or neuropathic joints may not be due exclusively to syphilis, but may also be observed in diabetes, tumors of the cauda equina, transverse myelitis, spina bifida, and other neurological disorders. The disease process in a neuropathic joint shows degeneration and partial dissolution of the articular cartilages. The bone tissue underlying the degenerating cartilages proliferates excessively with the formation of large, irregularly shaped masses of unorganized bone which may either infiltrate adjacent tissues, or else appear as free bone fragments.

Charcot's arthropathy may involve the spinal column where it shows the usual atrophy and degeneration of bone with the attendant extensive proliferation of bone into the surrounding spinal tissues. Calcification of the spinal muscles and ligaments is a common finding. The lumbar vertebrae are the usual site for

this disease. Not infrequently the overgrowth of bone may invade the vertebral canal to compress the spinal cord or nerve roots with a resulting paralysis.

FUNGUS INFECTIONS OF THE SPINE

1. **Actinomycosis** is a relatively common disease of cattle, and although rare in man it is widely distributed geographically and does occur most frequently in individuals whose work keeps them in contact with cattle. The disease is referred to as "lumpy-jaw" in cattle because the granulomatous lesions are found most frequently in the jaw and soft parts of the head and neck. In man actinomycotic lesions are usually located in either the head and neck, thorax, abdomen, or spine. Involvement of the vertebrae generally results from the spread of the disease from adjacent tissues and there is destruction of both bone tissue and periosteum which is frequently followed by bony sclerosis in the process of repair. Actinomycosis is very prone to affect the bone, and was formerly mistaken for osteosarcoma. The disease is chronic and the extensive formation of granulomatous tissue around the involved vertebrae forms a hard stone-like growth which tends to become necrotic in the center and suppurate. The pus contains the characteristic "sulfur granules" which are small, yellowish granular masses. In most cases, the pus is discharged onto the skin of the back by way of a sinus tract. Spinographs of vertebrae involved in actinomycosis show the centers of the bodies to have a honey-combed or worm-eaten appearance.

The clinical course of the disease associated with this "ray fungus" usually includes pain, tenderness, limited motion, and local swellings. It simulates osteomyelitis in some of its forms, and generally runs a chronic course with a high fatality rate from the effects of the infection or related reactions. It is considered that the usual portals of entry of this pathogenic fungus is through dental caries, pyorrhea, or infected tonsils. It is more common in people who live in rural areas, especially in men engaged in the cattle or dairy business.

2. **Blastomycosis** considered due to a yeast-like organism, Blastomyces Dermatitides. The disease exists in two forms: (1) a chronic infection of the skin, called Gilchrist's disease, and (2) Systemic blastomycosis which attacks bone and various viscera.

When the systemic form involves the vertebrae of the spinal column the bone destruction closely parallels that seen in a case of osteomyelitis or of spinal tuberculosis, and differentiation can only be made by analysis of the tissue pathology. It is considered that system infections are almost invariably fatal, though it may require several years to destroy life.

3. **Coccidioidal Granuloma** is associated with a pathogenic yeast, coccidioidal immitis. The disease is most common in the San Joaquin Valley of California, and is seen in Texas and Arizona. It very closely resembles blastomycosis except it is more acute and runs a more severe and rapid course. It usually invades the skin and the lungs in which locations it acts very much like tuberculosis. If it attacks the spinal column, there is destruction of the bone tissue, with sclerotic zones appearing as repair of the eroded vertebra proceeds. Most vertebral involvements are secondary to the initial paravertebral abscesses which drain into the spinal region.

PROTOZOAN INFECTIONS OF THE SPINE

Toxoplasmosis is the only known disease of bone associated with a protozoan. The infection is frequently found in animals, and may infect man usually during infancy, when it produces certain neurological signs including cerebral calcifications, microcephalus, hydrocephalus, and convulsions. If it appears in later life toxoplasmosis simulates Rocky Mountain spotted fever. The principal changes in the vertebrae are heavy bands of dense calcification in the upper and lower surfaces of the vertebral bodies, and these findings, with spotty areas of calcification in the brain, at least suggest the possibility of toxoplasmosis.

PARASITIC INFESTATIONS OF THE SPINE

The number of metazoa which are parasitic upon human bone is limited to but two or three definite forms, in spite of the great variety of animal parasites associated with human infestation. The outstanding member of this group is the **Echinococcus granulosis**, associated with **Echinococcosis**, or **Hydatid disease**. The echinococcus is the larva of the tapeworm of the dog. The parasite is transmitted to man from infected dogs or cats which are said to harbor the organism in the intestinal tract. Hydatid disease in

man predominantly attacks the liver with the formation of many "hydatid cysts" which are thick-walled spherical sacs filled with fluid and thousands of larvae. Rupture of a cyst usually produces severe reactions, or the pressure of the growing cyst may affect surrounding organs. The lungs are also frequent sites for developing cysts. The parasite reaches the bone of the vertebral column by way of the arterial circulation, and usually establishes itself in the cancellous bone of the vertebral body. Here it forms an **osseous cyst** which gradually weakens the bone by erosion of its structure. Although the cyst itself is not visible on the spinal X-ray, evidence of its destructive action is evinced by the small bubble-like cavities in the bone tissue. The intervertebral discs do not seem to be involved, but a common finding is that of spinal cord compression due to the encroachment of the cysts into the vertebral canal.

Another parasite which may invade the vertebral region, and by tumorous or cystic growth compress the spinal cord is the **Schistosoma mansoni**. This is a human blood fluke which is associated with the disease **Schistosomiasis**, or **bilharziasis**. It is primarily an intestinal irritant causing dysentery, and later, benign tumors. It is this tumorous collection of the parasites which may develop inside the vertebral canal to compress the cord, or, its toxic discharge may cause erosion of the vertebral bone tissue with which it comes in contact.

The **Cystericus cellulosa**, which is the larva of the taenia solium, or pork tapeworm, gains entrance to the tissues by ingestion of raw or partially cooked pork. The parasite forms multiple hard cysts each about the size of a marble, which cause pressure on local structures. The favorite sites of cyst development include the subcutaneous tissues, the eye, and the central nervous system and spinal canal. Many of the cysts undergo calcification and suppuration to either press upon or invade the tissues of the spinal cord or the bone of the vertebrae.

CALVE'S DISEASE

(Asceptic Necrosis of the Vertebral Body)

This condition is a non-tuberculous and non-inflammatory disease of the vertebrae. There is necrosis of the vertebral body without any indications of infection or inflammation, and later

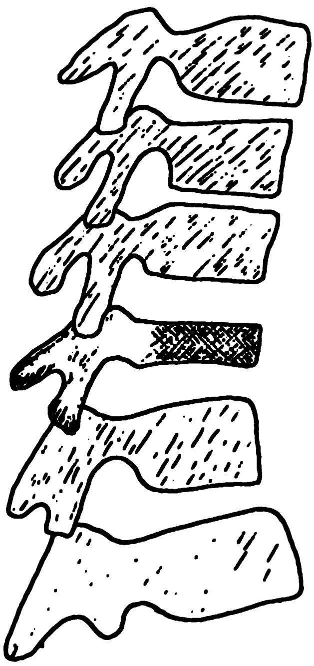
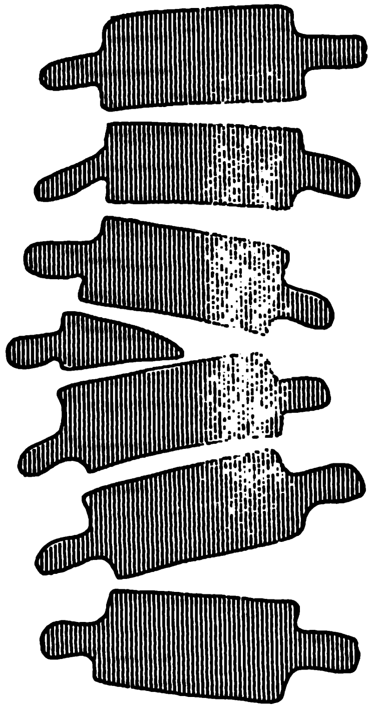


Fig. 89. Calve's Disease —the vertebral body has shrunk to about one-half its normal thickness, but the intervertebral disc has not been affected.



Hemivertebrae

a gradual regeneration of bone tissue takes place. It is considered the result of interference with the blood supply to the vertebrae which nutritional deficiency brings about an asceptic necrosis. The involved vertebra undergoes necrosis and secondary fragmentation until it finally collapses into a thin, flat disc of bone about one-fourth to one-half its normal thickness. This is usually followed by a slow and gradual regeneration of bone which restores the affected vertebra to nearly its original thickness. The disease is most apt to occur in children from two to fifteen years of age, particularly between the ages of five and ten. Clinical symptoms include an insidious onset of slight pain, tenderness, and muscle spasm over the involved vertebral region. Trauma is mentioned as a predisposing factor to Calve's disease. The spinographic X-rays reveal the thin flattened vertebral body, or bodies, as several vertebrae may be concerned, particularly in the lumbar and lower thoracic regions. The disease is sometimes referred to as vertebra plana because of the extreme flattening of the vertebral body. It appears to be a spinal form of Legge-Calve-Perthes disease, which is a rarefaction and flattening of the head of the femur. Similar lesions are described in the growing ends of other bones.

Although aseptic necrosis of the vertebral body may appear as the sole pathology, it is more commonly found in combination with other bone disturbances such as osteoporosis and bone malignancies. It may be difficult to differentiate the disease from tuberculosis of the bone, but a series of spinographs at regular intervals will show the gradual shrinking of the vertebral body, followed by bone regeneration characteristic of this condition.

THE EFFECT OF X-RAYS AND RADIUM UPON THE SPINAL COLUMN

The intensive use of X-rays or radium for purposes of therapy has a detrimental secondary effect upon the bone structures adjacent to the area being irradiated. Irradiation osteomyelitis is one of the most serious bone diseases resulting from such over-exposure. Because of sclerosis of the nutrient vessels, circulation and cellular activity are arrested resulting in a necrosis of the bone tissue. The use of X-ray therapy for malignancy in structures alongside the spinal column may yield serious bone disturbances in growing children. These defects include

retardation of bone growth with deformity of the spinal muscles and vertebrae, and atrophy of the overlying skin and fascia. Radium seems to have a similar effect upon the bone development when it is used in large doses.

The amount of radiation employed in the taking of spinographs, by the Chiropractor, could not possibly produce these destructive bone changes in any given patient when the simple rules to prevent such overexposure are followed by the Chiropractor. Staying within the recommended milliamperage second exposure range, and spacing a series of spinographs at regular intervals, should forestall any possibility of irradiation damage to bone tissue of the spinal column.

FLUORINE AND THE SPINAL COLUMN

Fluorine is the most active member of the halogen family of chemicals. The halogens are found in nature as compounds, being too active chemically to exist as free elements. Fluorine is usually found as the calcium fluoride, or is the double fluoride of sodium and aluminum, known as cryolite.

It is best known as an additive to water supplies under the process known as fluoridation which is said to help prevent tooth decay.

However, fluorine is known to have a cumulative effect in the human body when ingested or inhaled in large amounts, and its site of primary attack is bone tissue. Sclerosis and greatly increased density of the skeleton are common findings in fluoride poisoning. The vertebrae, as well as the other bones, show thickening, roughness, brittleness, and increased porosity. The intervertebral discs undergo ossification, and in time, much of the spinal column may be fused by ankylosis.

Most cases of fluoride poisoning can be traced to an occupation in which the workman is exposed to fluorine in one of its forms over an extended period of time. However, it will be interesting to follow the rate of incidence of fluoride poisoning in the coming generation, and to see if any relationship is expressed between vertebral defects and the common practice of fluoridation. The Chiropractor, by virtue of his concentration upon spinal diseases, is admirably fitted to detect any such trend.

Chapter 11

CONGENITAL DISORDERS OF BONE

One cannot but think that the many disorders of bone arising congenitally are the net results of developmental interference. Many of these conditions deserve a rightful place in the study of malformations of the spinal column because of their involving the vertebrae, but many others are obscure and far removed from the bones of the vertebral column. These are best left to texts dealing with bone pathologies.

Authorities are in disagreement as to the causes of even the most common of these disorders and are prone to consider many variables of pathological processes. The Chiropractic understanding of these congenital disorders may be explained simply and clearly on the basis of nerve interference. Such interference in the mother may have a profound effect upon the developing skeletal structure of the fetus by depriving essential growth products. Again nerve interference in the fetus may prevent proper assimilation and utilization of growth products, or, it may result in improper developmental processes. The final result is the same—a congenital bone disorder; whether described as either the clinical entity of osteopetrosis or that of achondroplasia, it still must have a single cause. There may be many contributing factors to bone disorders, but the fact remains that the over-all cause must apply to each and every disease of congenital origin.

Obviously, in some few cases, the limitations of matter, and the powers of intellectual adaptation, may be overwhelmed by certain concussions of force, and bone diseases may appear congenitally as a result. For example, the maternal bloodstream made highly toxic by the injudicious use of certain drugs might seriously disturb the formative processes of the developing embryo or fetus, but this is the exception rather than the rule. All things being equal, the cause lies in interference with the normal

transmission of mental impulses either in the mother, or the child, or both.

1. Achondroplasia

This is the result of a congenital defect in the development of the cartilaginous skeleton with faulty ossification affecting the growth of the long bones. The cartilage cells at the epiphysis of long bones are arranged irregularly, rather than in long columns as is normal. The result is an enlargement of the ends of the long bones with characteristic shortening of the arms and legs. The trunks of these persons are of normal proportions and their mentality is not usually affected. Because of the hereditary tendency toward transmission of the condition from one generation to the next, it is considered a dominant hereditary characteristic, and the dachshund and certain short-legged breeds of sheep and cattle are considered as examples of such dominants in the animal kingdom.

Achondroplasia is characterized by short arms and legs and a long trunk. The hands are short and broad, the central three fingers of equal length (trident hand). The head is uniformly enlarged, the nasal bridge is depressed, and there is enlargement of the articular extremities of the long bones. Comparison by X-rays will show a clear, thick outline of the epiphyses of the long bones in achondroplasia, whereas in rickets the growth line is hazy and irregular.

Achondroplasia is the most common form of dwarfism, and seems to affect females somewhat more frequently than males. The vertebral bodies are usually thinner than normal, and the intervertebral discs are thicker, with the result that spinal curvatures often appear. Sacralization and wedging of the fifth lumbar between the iliac bones is not uncommon. Anomalies of the occiput, atlas, and axis are frequently observed in this condition, and narrowing of the neural canal is often seen, which narrowing may be sufficient to compress the spinal cord with attendant symptoms of nerve interference. The unusually large intervertebral discs may bulge and protrude into the neural canal, and in this way, cause spinal cord pressure. Achondroplasia is also called fetal rickets, chondrodystrophia foetalis, and micromelia.

2. Dyschondroplasia

This condition is characterized by the abnormal growth of cartilage at the diaphysial end of long bones, with the formation

of cartilaginous and bony tumors on the shafts of the bones near the epiphyses. It differs from achondroplasia in that it affects the diaphyseal area; whereas in the latter, the epiphyses are involved.

Dyschondroplasia is considered as a hereditary skeletal dystrophy, and is well known as Ollier's disease. Other names applied to this condition include multiple cartilaginous exostoses, skeletal enchondromatosis, hereditary deforming chondrodysplasia, diaphysial aclasia, and dysplasic chondromatosis.

The outstanding characteristic of dyschondroplasia is dwarfism with its accompanying clinical picture closely paralleling that of achondroplasia. The disease, however, does not usually affect the vertebral column, and this fact, plus the location of the disturbance of bone growth in the diaphyses, helps to differentiate it from achondroplasia.

3. Osteochondrodystrophy

Osteochondrodystrophy is considered a hereditary developmental defect characterized by excessive cartilage formation, and deficient ossification of many of the bones. In most cases, the outstanding feature is dwarfism, deformities of the bones of the trunk and the extremities and abnormal joints of the feet, hips, and knees. The skull is usually not malformed.

Although the condition is considered due to an unknown cause, it tends to run in families, and basically may be considered the result of defective germ plasm. Perhaps no other disease has as many synonyms applied to it as is found in osteochondrodystrophy, which is also called Marquis-Brailsford's disease, chondrodysplasia, osseous dystrophy, atypical achondroplasia, rachitic chondrodystrophy, dyschondroplasia foetalis, congenital perversion of growth, and familial osteochondrodystrophy, among others.

The typical case of osteochondrodystrophy appears quite normal during the growth period until the fourth or fifth year, after which growth may cease and malformation of the trunk and extremities appear. The outstanding feature is that of a dwarf-like shape, short neck and trunk, kyphosis, and deformed arms and legs. The knee and hip joints are unusually large and flexible so that the person stands with the pelvis tilted forward, knees slightly flexed, and head sunken between the shoulders. The mentality is usually normal.

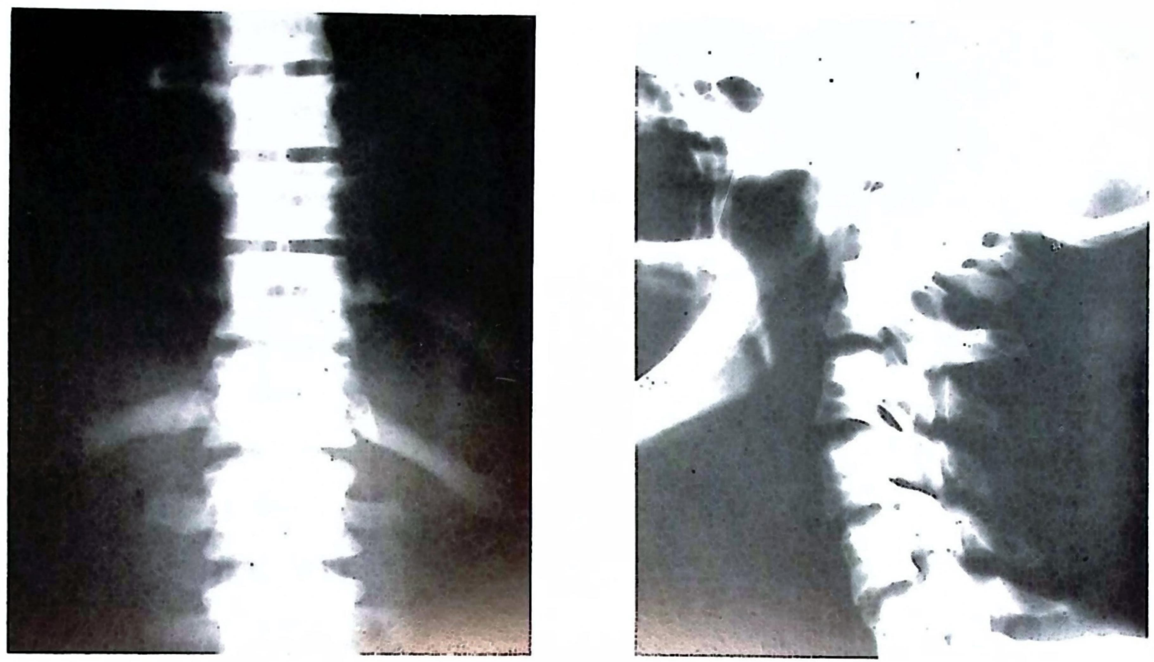


Fig. 90. Case of Osteopetrosis or "marble bones." Note the increased density of the vertebral bodies.

The malformations in the vertebrae are mainly due to distortion of the epiphyseal plates and delayed ossification. The joint surfaces of the vertebral bodies are flattened, and elongated from anterior to posterior. The intervertebral spaces are widened, so that the vertebral bodies appear to be only one-half as thick as normal. This inequality of size tends to produce severe spinal curvatures, particularly a kyphosis.

The bone structures of the arms and legs are distorted due to disturbances in ossification and hyperplasia of cartilage.

4. Osteopetrosis

Osteopetrosis is also known as **marble bones, ivory bones,** and **Albers-Schonberg disease.** It is considered a congenital defect in which there is condensed bone at the epiphyseal lines of long bones, and condensation of the edges of smaller bones. There is a great increase in the density of the bone with a lessening of the marrow which yields an osteosclerotic anemia. However, chemical analysis of the bones shows relatively normal balance of phosphorus, calcium, magnesium, and carbonates, although these minerals may be greatly increased in amount. In spite of the apparent density of the bones, they are chalky and tend to fracture easily. The term **marble bones** is well taken as X-rays of the spinal column show the individual vertebrae standing out in bold relief, as though cast in marble. The vertebral bodies appear relatively normal as do the intervertebral spaces. A common sequel to progressive, severe osteosclerosis is narrowing of the optic foramina by the encroaching bone tissue which, in time, may cause blindness by pressure upon the optic nerves.

5. Osteogenesis Imperfecta is also know as Fragilitas Ossium.

It is a fairly common hereditary disease involving those tissues which develop embryologically from the mesoderm. It is characterized by thinness and brittleness of bones resulting frequently in multiple fractures, maldevelopment of other connective tissues, and very pronounced blueness of the sclera of the eye. It is probable that this discoloration is caused by pigment in the choroid coat shining through the abnormally thin sclera. This bluish discoloration is referred to as **Lobstein's disease** or **Syndrome,** and if deafness due to otosclerosis is present, the ear involvement is called **Van Der Hoeve's Syndrome.** The disease shows marked variations in its clinical picture. The typical case

of osteogenesis imperfecta is short of stature, appears poorly nourished, and presents many bony deformities and multiple fractures which occur upon the slightest trauma. The skull is somewhat flattened as the vertex, and the chin is narrow and pointed so that dentition is retarded. Muscular development is poor and the joints are relaxed, and they exhibit unusual freedom of movement. These symptoms, in addition to the blue sclerae and loss of hearing, are quite characteristic of a moderately advanced case.

Two types of osteogenesis imperfecta are recognized clinically:

1. **Osteogenesis Imperfecta Congenita**—in which fractures of the bones occur in intra-uterine life and the child is born with deformities.

2. **Osteogenesis Imperfecta Tarda**—in which the fractures occur when the child begins to walk. In both forms the fractures heal with an excess of callus formation, but do not ossify properly.

The pathology associated with the condition shows imperfect formation and calcification of the bony trabeculae, although the calcium and phosphorus content is normal. Small collections of cartilage are observed beneath the periosteum and these formations replace normal bone which is scattered irregularly through the structure. The medullary part of the bone is partly fatty or fibroid. Because of their lack of osseous tissue, many of the weight bearing bones show a shortening and thickening due to their collapse, and may present an irregular, accordion-like shape as a result of this collapse.

The spinal column shows marked changes in osteogenesis imperfecta with the vertebral bodies being markedly flattened and broadened, and widening of the intervertebral spaces. The vertebral bodies are frequently biconcave above and below, and their outline is accented by bony contrast with the cartilage inside. In most cases there is a definite scoliosis and kyphosis from the deforming compression of the vertebral bodies. Fractures of the vertebrae are frequently found as well as in other bones. Osteogenesis imperfecta, as the name implies, may be considered as a developmental arrest in which the vertebrae and other bones are preformed in cartilage, but fail to undergo adequate and proper ossification because of lack of regulation of the osteoblasts.

It is known variously as brittle bone, osteopsathyrosis, osteosclerosis, idiopathic fragilitas ossium, periosteal aplasia, and periosteal dysplasia.

6. Fibrous Dysplasia or (Polystotic Fibrous Dysplasia)

This condition is considered a congenital developmental anomaly and is marked by thinning of the cortex and gradual replacement of the bone marrow by small particles of fibrous tissue and spicules of bone. The condition produces pain, disability and a gradually increasing deformity. The progress of the disease is slow, and the first indication may be a tendency toward fracture upon slight trauma to the bone. The skull bones are most likely to produce striking changes, eventually resulting in gross deformity of the face.

Involvement of the vertebrae is relatively infrequent, but when present the disease produces such changes in the vertebral bodies as decreased thickness and scattered areas of decreased bony density. The intervertebral discs are frequently widened and concave on their superior and inferior surface. X-rays of the affected bones show well defined clear areas which have a characteristic homogenous or "ground-glass" appearance.

7. Arthrogryposis

The literal meaning of arthrogryposis is a crooked or bent joint, and the term is used to designate multiple contractures of the joints. The condition is congenital in most cases. The joints of the extremities are most commonly involved, and show a thickening of the tissues around the joints as well as an atrophy and fatty infiltration of the involved muscles. The joints are stiff and contractured, and appear thick and distended, although pain is not a common symptom. The bone structures are elongated and thinner than normal and seem unusually susceptible to fracture.

Although this condition rarely produces a demonstrable pathology in the vertebrae, it does indirectly affect the spinal column by means of the muscle contractions which produce spinal imbalance and curvatures.

8. Mongolism

This is a form of congenital, mental deficiency in which the person has a mongolian cast of countenance, the nose being

broad, the eyes slanting, and the skull flat. Along with mental retardation, there is poorly developed musculature and lack of coordination. Although the vertebral column shows no specific changes, mongolism may be a contributing factor to scoliosis by causing muscular weakness and imbalance.

Chapter 12

METABOLIC DISEASES OF BONE

It will be noted by careful consideration of the fundamental histological changes taking place in bone tissue resulting from metabolic disturbances, that they all present rather similar changes. Either the osteoblasts or the osteoclasts are deranged in their functions, or else mineralization of bone tissue is decreased or increased, and frequently there is a combination of both cellular and inorganic imbalance.

In any event, the Chiropractic understanding of such metabolic disorders in bone is based upon nerve interference along the pathways of control from the brain to the involved tissues of digestion and assimilation. It is safe to assume that if the daily intake of food is sufficient and varied, the metabolic disturbance of an individual would not exist, and yet, the fact that they do exist is shown by the high rate of prevalence of these disorders. Many such cases develop in people enjoying an economic position in life that makes adequate food intake a matter of course. The repercussions of starvation or inadequate diet upon bone disorders cannot be denied; but all these things being equal, the great majority of metabolically induced disorders of bone can be explained upon the basis of improper utilization of available food material. If nerve interference prevents proper secretion of digestive fluids, or proper absorption of digested food, or proper assimilation of digested food, the result is an abnormal structure of bone. There is either too little or not enough of the normal constituents of bone tissue and the bone is considered to be in a state of disease.

Correction of the cause of this condition by Chiropractic care in the early stages can do much to bring about normal changes. Obviously, if extensive distortion and malformation has already taken place such as in severe rickets, the limitations of matter

will prevent a return to normal size and shape of the affected structures.

1. Osteoporosis

Osteoporosis is a metabolic disturbance of bone tissue in which the osteoblasts fail to form bone matrix. The chemical equilibrium of calcium and phosphorus is not disturbed, but rather, the disorder results from improper osteoblastic activity. Microscopic examination of the bone shows the compact bone to be thinner than normal, and the trabeculae of the cancellous bone are more widely separated. The red bone marrow is diminished in amount, being replaced to a large degree by fatty material. There is increased porosity and softening of the bone with widening of the Haversian canals.

Osteoporosis may follow prolonged disuse, trophic changes, wasting diseases, and phosphorus poisoning. As it may develop in starvation, it is sometimes called "hunger atrophy." Among other possible contributing factors to osteoporosis are such nutritional deficiencies as may occur after the menopause, or in old age; others include various glandular disorders such as hyperthyroidism, acromegaly and ovarian insufficiency. Also, an unusual form of osteoporosis may follow traumatic disorders of the vasomotor system. This follows an acute course and is known as **Sudeck's atrophy.** The vertebral bodies are frequently attacked in osteoporosis, and the first indication is seen on X-rays which show **demineralization of the bodies.** They appear normal in shape, but have a dense peripheral outline surrounding a shadowy, less dense center. As the condition progresses, it is not uncommon for the involved vertebral bodies to become so weakened that they collapse, and the intervertebral spaces between them become wider. The vertebral bodies may become concave on their upper and lower surfaces due to their inability to resist the compression of the intervening fibro-cartilage which, in turn, assumes a biconvex appearance.

Osteoporosis of the vertebral column presents a similarity to other bone disorders, including osteomalacia, myeloma, and hyperparathyroidism, so that X-ray analysis of the pathological picture may be inconclusive and clinical manifestations of the possible diseases must be considered.

2. Osteomalacia

In its simplest definition, osteomalacia is a softness of the bones because of defective calcification. The disease is variously

known as **mollities ossium** and **malocosteon.** It is a disease marked by increasing softness of the bones so that they become flexible and cause deformities. It is attended by rheumatic pains, anemia, and malnutritional symptoms so that eventually the patient becomes weak and may die of exhaustion.

Any condition which drains the body's calcium stores sufficiently can contribute to osteomalacia. Such depletion may take place through excessive loss of calcium, or through inability to properly assimilate calcium. In spite of this disturbed calcium metabolism, analysis of the blood chemistry shows a relatively normal serum calcium level and serum phosphorus level. All indications point toward the probability that a typical osteomalacia is nothing more than a case of adult rickets as it occurs mostly in adults. It is rare in the male, only 8 per cent, and is particularly common in women during pregnancy or the puerperal period. The bones become distorted and break with greater ease than normally, and often fail to heal properly after fracturing.

The bones most commonly affected in this condition are: lumbar vertebrae, pelvis, and the bones of the legs. The pelvis is generally much distorted, being compressed laterally with the pubes passing forward, thus giving it a triangular shape and making child-bearing difficult.

The patient is weak and emaciated, and complains of pain in various parts of the skeleton. There is a peculiar waddling gait. Mental symptoms may include irritability and poor memory. The vertebrae exhibit a pronounced demineralization with concave upper and lower surfaces of the vertebral bodies, and much enlarged intervertebral discs.

3. Rickets

Rickets, or rachitis, is a metabolic deficiency disease of bone occurring during infancy and early childhood. There is a failure of ossification of osteoid tissue and of bone development due to improper absorption or assimilation of calcium. Excretion from the intestinal and urinary tracts shows an increased phosphoric content, and analysis of the blood discloses a reduced amount of serum phosphorus. Essentially, the histo-pathological picture is the same as occurs in osteomalacia. The spinal column is frequently affected by rickets with the vertebral bodies showing

Fig. 91. Skeleton showing a case of rickets.

decreased bone density and softening as evidenced by the tendency toward compression and thinning of the bodies. There is a corresponding widening of the intervertebral spaces. Spinal curvatures of lordosis, kyphosis, and scoliosis are common because of the bone deformities and the muscular weakness which accompany rickets. In fact, the term rachitis was originally interpreted to mean an inflammatory disease of the vertebral column. Rickets also produces characteristic changes in other growing bones, particularly the long bones. These show widened epiphyseal zones, with wide areas of hazy outline resembling a fringe at the junction of the metaphyses. The epiphyses appear decreased in density and the metaphyses are broad and thick. These changes are most obvious in the lower ends of the radius, ulna, tibia, and fibula. Rickets should be suspected in children between the ages of six months to three years who develop knock knees and bowlegs, along with a history of faulty feeding, restlessness at night, and progressive deformity.

The shape of the legs is profoundly altered by rickets and it commonly causes **genu varum** (bowlegs), **genu valgum** (knock knees), and a bowing of the leg forward, the so-called **saber shin.** These distortions are due to compression of the weakened bones by the body weight.

The clinical manifestations of rickets follow a rather definite pattern in most cases. There is a restlessness during sleep to the extent that continuous rolling of the head may wear the hair off the back of the head. Sweating is a common symptom. The digestive system is upset, with constipation and poor appetite. The liver and spleen are frequently enlarged, and a protruding abdomen is a constant finding. Diffuse tenderness and soreness of the body, with muscular weakness, is common. Dentition is delayed and the teeth are badly formed. The fontanelles of the skull delay closure for several years. The skull bones are often so thin (craniotabes) that they crackle like parchment when pressure is applied. The head is enlarged and square in shape, the so-called **caput quadratum.** Nodules can be felt at the sternal ends of the ribs, the **rachitic rosary.** As the bony deformities of rickets progress, a transverse depression of the chest (Harrison's groove) may appear, which is caused by softening of the cartilages between the ribs and the sternum. The groove occurs along the line of the diaphragmitic attachment. There is an outward flare of the lower border of the ribs, and the sides of the thorax are flattened. Occasionally, the chest

deformity advances to a point in which the lower portion of the sternum is depressed deeply (**funnel chest or pectus excavatum**). In some cases, however, the sternum may protrude prominently in front (**chicken breast or pectus carinatum**). The rachitic pelvis is much distorted, and is known as a flat or platypelloid pelvis. When the girl with rickets begins to walk in early childhood, the weight of the trunk tends to flatten the pelvis. The sacral promontory is forced toward the symphysis pubis, and the ilia are forced laterally so that the transverse diameter is greatly increased. The contributing factors to rickets may be summed up briefly.

1. A deficiency of Vitamin D
2. A deficiency of inorganic salts, chiefly calcium phosphatic
3. Lack of sunlight

4. Renal Rickets or Renal Osteodystrophy

This condition produces gross deformities somewhat similar to infantile rickets. It may appear in early childhood, but the average onset of renal rickets is about seven years. The early symptoms include loss of appetite, headache, vomiting, excessive thirst, and polyuria. Urinalysis indicates severe insufficiency of the kidneys, and the blood shows elevation of blood phosphorus and decrease of the blood calcium level. The skin is frequently discolored to a greenish or yellowish hue.

This condition is also known as **Glomerular Rickets** and because of the extensive impairment of the kidneys the ultimate outcome is death from uremia, usually during adolescence.

The spinal column and the bones of the extremities are affected. Virtually the same changes in bone tissue which accompany infantile rickets may be observed in this disease. Probably the changes observed in X-rays are the result of faulty depositing of minerals in the bony structures due to inability of the kidneys to excrete phosphates. The condition is said to be due to chronic renal diseases, such as nephrosis, glomerular nephritis, and pyelonephritis. Also included as possible causes are obstructions in the ureters or urethra, and congenital malformations of the kidneys. The para-thyroids are frequently involved to the extent that there is a formation of excess parathyroid hormone.

5. Fanconi's Syndrome

Fanconi's syndrome (Renal Tubular rickets with glycosuria) shows rachitic changes in the bones and renal glycosuria accompanied by amino-aciduria. The primary factor is disease of the kidney tubules which fail to reabsorb phosphorus, glucose, and some amino acids in normal quantities. The bone phosphate is gradually depleted by the excessive loss of phosphorus in the urine.

The clinical picture in Fanconi's syndrome closely parallels that of infantile rickets but usually appears in late childhood rather than infancy. Development is retarded and the bones show multiple deformities with rachitic enlargement of the epiphyses.

Analysis of the blood shows the serum calcium to be normal but the serum phosphorus is low. The urine contains glucose.

(6) Coeliac Rickets

Typical rachitic changes in the bones may be observed in coeliac disease which is a digestive disorder distinguished by an excess of fat in the stools. The intestinal tract is unable to properly absorb fats which seems to upset the bone metabolism.

The disease is noted early in childhood with features of impaired growth, wasting, muscular weakness, and loose stools containing 40 to 80 per cent fat after drying compared with the normal 25 per cent. Examination of the blood shows the serum calcium to be low and the serum phosphorus to be normal or slightly lowered.

7. Scurvy

Scurvy is variously known as acute rickets, infantile scurvy, scurvy rickets, and Moeller-Barlow disease. It is considered to be a combination of rickets and scurvy, either of which may predominate, and is metabolic in origin.

It occurs between the sixth and twelfth month, and is due to lack of the antiscorbutic Vitamin C. The symptoms of rickets may or may not be marked when the scorbutic features predominate. It is manifested by spongy, bleeding gums, and hemorrhages into the skin, the subperiosteal tissues, and the joints. An epiphysis is sometimes separated from a diaphysis by hemorrhage, and the pain and swelling caused by this, or by bleeding beneath the periosteum is quite severe. Fractures of the shafts of the long bones are quite common. In the infant, there is frequently the appearance of beading of the costochondral margins the same as found in rickets.

Scurvy alone seems to produce no changes in the appearance of the vertebrae, but in combination with rickets, the typical demineralization may be observed.

8. Ochronosis

This is a metabolic disease characterized by a bluish discoloration of the cartilage. The discoloration is, therefore, noticeable where the cartilage is situated near the surface of the skin as on the nose, the knuckles, and ear lobes.

The condition appears in middle life and affects both sexes equally. The first symptoms are those of malnutrition, soon followed by a state of gray, brown, or black pigmentation of the skin, ligaments, cartilages, and fibrous tissues. The urine is unusually dark or brownish-black in color. Ochronosis affects the spinal column by producing a generalized calcification of most of the intervertebral discs. This is a constant symptom. Other spinal changes include ankylosis and curvatures, particularly a kyphosis.

9. Hypervitaminosis

In these days of self-medication, along with the popularity and availability of vitamins, it is not uncommon to observe indications of excessive intake of vitamins. An excess of Vitamin A in the body may directly affect the spinal column to the extent

that noticeable decalcification of the vertebral bodies appears. Vitamin D in excessive amounts has been known to contribute to calcium infiltration of the spinal musculature with attendant ankylosis.

10. Paget's Disease

Paget's disease of the bone is also known as Osteitis deformans and Senile rickets. The mechanism underlying the bone changes typical to this condition are unknown so that for all practical purposes it may be included under metabolic diseases in view of its similarity to infantile rickets.

The outstanding characteristics of Paget's disease include a slow rarefying and softening of the long bones, with deformation and enlargement of the flat bones of the skull and the vertebrae of the spinal column. There is a definite tendency toward malignant degeneration of the involved bones as the disease progresses. Paget's disease usually appears after the age of forty. The cranium enlarges and is eccentrically thickened by obliteration of the sutures, but the facial bones are not usually involved, so that the shape of the head resembles an acorn or a triangle with the base upward. The patient diminishes in height, owing to kyphosis and outward curvature of the extremities—the result of greater physical stress upon these already softened structures. The thickening and bowing of the long bones of the leg are more or less symmetrical. Osteoid tissue forms along the convex surfaces of these curved bones, but it is porous, weak, bone tissue.

The chest is sunken and the pelvis broadened. The patient complains of persistent pain in the bones, along with rheumatic pains, and has an awkward, swinging gait, like an ape.

The pelvis and lumbar spine are frequently affected. In the early stages, there is bone resorption, followed by fibrous proliferation in the marrow which gives a pathological picture quite similar to osteitis fibrosa cystica. However, the pathology in Paget's disease is prone to develop into malignancy.

The microscopic or histopathological changes in the bone follow a rather definite course. Initially, there are many irregular islands of newly formed bone tissue, which undergo rapid destruction and absorption, only to be replaced by more bone islands. These rapid cycles of bone formation and destruction

eventually lead to a secondary fibrosis of the marrow. Finally, there is softening and giving way of the bone with progressive deformity. The lumbar vertebrae and the sacrum are most frequently the location of osteitis deformans when it attacks the spinal column. Compression of the spinal cord and the cauda equina may accompany the overgrowth of osteoid tissue in these areas. As mentioned previously, Paget's disease has a tendency to become malignant, and cancerous degeneration of the vertebrae is not uncommon, particularly of the sarcomatous type.

The gross changes of the affected vertebrae show a grain-like coarsening of the cancellous bone tissue of the vertebral body. The periphery of the body is thicker than usual, and of increased density. The pedicles and laminae tend to become enlarged, but it should be remembered that all such hypertrophy is brought about by the overproduction of unhealthy bone tissue. In the later stages of the disease, it is not unusual for these enlarged, softened vertebrae to partially collapse or undergo compression shrinkage which accounts for the diminished height of the individual. The intervertebral discs show no unusual changes in Paget's disease.

FINDINGS IN THE VARIOUS FORMS OF RICKETS

	Contributing Factors	Serum Calcium	Serum Phosphate	Stools	Urine
Infantile Rickets (children) Osteomalacia (adults)	Impaired absorption of phosphorus and calcium. Vitamin D deficiency.	Normal	Low	Normal	Normal
Renal Rickets	Impaired glomerular function—retention of phosphorus—excretion in bowel—combines with calcium preventing its normal absorption.	Low	High	Normal	Albumin
Fanconi's Syndrome	Impaired reabsorption of phosphates by renal tubules—excessixe excretion of phosphates.	Normal	Low	Normal	Glucose Excessive Phosphates Amino acids
Coeliac Rickets	Digestive deficiency—impaired absorption of Vitamin D and calcium.	Low	Normal	Fats to excess	Normal

Chapter 13

ENDOCRINE DISTURBANCES OF BONE

1. Hyperparathyroidism (Parathyroid Osteodystrophy)

Is a condition in which an excessive amount of parathyroid hormone is secreted. It is otherwise known as **Osteitis fibrosa cystica and Von Recklinghausen's disease.** There may be a general hypertrophy of all the parathyroid tissue, but in most cases, the underlying pathologic change is one of an adenoma. This tumor is smooth, elastically firm, and moves with the thyroid gland as a rule. The subjective symptoms include pain in the back and extremities, muscle weakness, changes in the gait, and finally pathologic fractures due to local decalcification of bones, which latter condition is known as **true osteitis fibrosa cystica.**

The analysis of the blood shows an increase in the blood calcium, decreased blood phosphorous, increased excretion of calcium in the urine, and an increase in the serum phosphatase. Evidently, the excess of parathyroid hormone tends to free calcium from the body tissues, including bone, and the loss of calcium through the urine is so great that decalcification of bone tissue is a compensatory reaction in an attempt to balance the blood calcium and phosphorous content.

Although osteitis fibrosa cystica is now considered an endocrine disorder of bone, it was classified until recently, as an inflammatory disease of bone, oftentimes with a syphilitic background. Its outstanding feature is an extensive absorption of the osseous tissue with fibrous changes in the bone marrow, giving rise to a whitish or reddish-brown tumor containing cellular masses and giant cells—the so-called osteocastomas. This fibrous tissue usually melts down in places, thus forming multiple cysts containing serous or serosanguinous fluid and is known as **osteitis fibrosa cystica.** If the fibrous tissue becomes

hardened and undergoes eventual ossification, the condition is termed **osteitis fibrosa osteoplastica.**

Osteitis fibrosa cystica is also known as Albright's disease. The disease may occur at any time of life in either sex, but is more frequent in females between the ages of 20 to 40 years. It may exist insidiously for many years, with the first indication of its presence being deformities and fractures. The musculature of the body loses a noticeable degree of tonicity and weakness is a common symptom. Loss of appetite, nausea, vomiting, and abdominal pain are other common symptoms. Deposits of calcium, called metastatic calcification, may be deposited in various viscera, including the heart, lungs, intestines, and kidneys. The bones involved show a diffuse form of osteoporosis, and although the entire skeleton may be affected, the humerus, femur, tibia, jaw and skull bones are the frequent sites of abnormal changes.

The endocrine imbalance of hyperparathyroidism may give profound changes in the vertebrae. A common finding is demineralization and osteoporosis of the vertebral bodies. The demineralization frequently results in the formation of a dorsal kyphosis and apparent shortening of the neck due to a cervical lordosis. The vertebral bodies frequently collapse and are compressed to about one-half of their normal thickness, but the intervertebral discs seem to be normal and unaffected.

When osteoporosis is present, the vertebral bodies tend to be compressed into a biconcave appearance above and below with attendant bulging and biconvex form of the intervening intervertebral discs. Aside from the usual bone changes mentioned above, it is held that osteitis fibrosa cystica may also be responsible for leontiasis ossium and osteitis deformans.

2. Acromegaly (Marie's Disease)

Acromegaly is a chronic disease characterized by enlargement of the bones and soft tissues of the face, hands, and feet. The disease is associated with over-function of the anterior lobe of the pituitary gland due to eosinophilic adenomas. All parts of the body are enlarged in acromegaly, which is considered the adult counterpart to the gigantism of youth. The hands are spade-shaped with thick, sausage-like fingers. The head takes on a hexagonal shape; the mandible protrudes to a marked de-

gree (prognathism), the teeth are flaring and separated, and the tongue becomes markedly enlarged. The features are coarsened, and the nose, ears, and lips are thickened. The spinal column is frequently kyphotic; and this, combined with the enlarged head, hands, and feet produces an attitude resembling a gorilla. The thyroid gland often shows enlargement. The mentality of the patient is not impaired, the principal subjective symptoms being headache and malaise. Hyperglycemia and glycosuria are present in the early stages, while in the late stages there is hypoglycemia.

Acromegaly usually appears after the age of thirty and may progress slowly for many years. However, in many cases, death occurs within ten years due to cachexia and degeneration of the cardio-vascular system.

The changes in the vertebrae of the spinal column associated with acromegaly show an increase in their antero-posterior dimensions, with but little increase in their height. As a result of the stimulation by an overabundance of the pituitary hormone, the periosteum on the anterior surface of the vertebral bodies seems to proliferate new bone more freely than is normal, which tends to make the vertebral body unusually wide in its anterior to posterior directions. This new bone can be seen as separated by a thin line of demarcation from the vertebral body's original margins. The intervertebral discs retain their normal thickness, but show an increase in their antero-posterior measurements to compensate for the changes in the bodies.

3. Cretinism (Hypothyroidism)

Hypothyroidism is the result of diminished secretion of the thyroid hormone. When it appears in the juvenile or congenital form, the term cretinism is applied, whereas myxedema is used to describe the adult or acquired form. It is marked by a dystrophy of the bones and soft tissues along with arrested mental and physical development. The basal metabolism is usually lowered.

The distinguishing features of cretinism usually appear from six months to a year after birth when it becomes evident that the child is not developing physically and mentally. The body is small, in fact it is dwarf-like. The child is sleepy, sluggish, good-natured, and mentally deficient to the point of idiocy.

The forehead is wrinkled, the eyelids thickened, the mouth is usually open with the much enlarged tongue protuding from it. The lips are thick and puffy, and drooling is common. The hair is usually scant, dry and coarse. The closure of the fontanels may be greatly delayed, and the skin is thick and dry. The pulse is slow and the body temperature is sub-normal. The abdomen is usually protuberant.

Myxedema, or mucus edema, develops in later life and occurs in the ratio of five female cases to every male case, and manifests itself between the ages of thirty and sixty years. There is a non-pitting edema of the subcutaneous tissues due to infiltration with a mucin-like substance. The facial expression is dull and listless, the eyelids are puffy. The tongue is thick and enlarged, the hair is dry, coarse and brittle. The mentality is retarded, and lethargy appears to the point that physical exertion becomes difficult or impossible.

Cretinism is much more likely to cause bone changes than the later developing myedema because of its presence during the formative years. Typically, the cretin displays retarded dentition, along with lack of formation of the epiphyses of the knees, elbows, and wrists. The outstanding changes in the spinal column of the cretin include an osteporosis and incomplete development of the individual vertebrae which generally leads to spinal curvature, particularly a kyphosis. Frequently, there is wedging of the vertebral bodies resulting from retardation of ossification. Another finding is an increased density of the superior and inferior surfaces of the vertebral bodies with decreased density in the central area.

4. Progeria

In the Simmonds and Hutchinson-Gilford syndromes, infantilism is combined with premature senility. The child has the facial features of an old individual. It is considered as a probable endocrine disorder, and there is marked stunting of height, so that a child of ten may have a height of only three feet. A withered, wrinkled skin may appear by the age of ten, the nose become peaked, the lips thin, and a blue network of veins may be visible over the temples. The fat of the cheeks disappears and loss of the eyebrows and baldness may appear. There is advanced arteriosclerosis in most cases, and genital

hypoplasia. The entire skeletal structure is retarded in growth with osteoporosis being a common finding. The vertebrae show a tendency toward incomplete development and deficient ossification, so that their appearance is quite similar to that found in cretinism.

5. Cushing's Syndrome

Cushing's syndrome is also known as pituitary basophilism, and is a disease of the endocrine system. The pituitary, adrenals, and parathyroid glands are all frequently disturbed in this condition. The syndrome may be due to pituitary basophilism hyperplasia of the adrenal cortex, cortical adrenal tumor, or parathyroid disturbance. The usual symptoms of the disease include hypertrichosis (excessive hair formation), increased fat localized chiefly to the trunk, face, and neck, purple abdominal striae, high blood pressure, retarded sexual development and a form of diabetes which will not respond to artificial insulin. The patient is often drowsy and irritable, with marked muscular weakness. Excessive thirst and polyuria are common symptoms, along with glycosuria and hyperglycemia. In females, amenorrhea is common, and in the male, sexual impotence may be observed.

The outstanding bone change in Cushing's syndrome is one of osteoporosis due to associated hyperparathyroidism. These osteoporotic changes closely parallel those found in hyperparathyroidism, so the main difference between the two diseases rests upon the clinical symptoms which are quite dissimilar. The spinal column frequently shows an extensive osteoporosis in Cushing's syndrome. The vertebral bodies may show evidence of compression due to the decreased bone strength, and they appear diminished in height with curvatures resulting from distortion.

Chapter 14

TUMORS OF THE VERTEBRAE

Tumors of bone may be benign or malignant. The **benign tumors** include those which are not cancerous and do not spread to the rest of the body. The most important benign tumors of bone are osteomas, fibromas, chondromas, myxomas, and giant cell tumors.

A **malignant bone tumor** is a cancerous one, and if unarrested, it will in time metastatize; that is, cells from the tumor will break off and move to other parts of the body where they will take root and grow in another organ or tissue. The most common primary malignant tumor of bone is the sarcoma, although bone may be invaded secondarily by carcinoma from the breast, prostate, and thyroid gland. From this it will be seen that malignant bone tumors may be either primary or secondary, the latter also being known as metastatic.

A **primary bone tumor** is an original tumor, that is, it is the first to appear in any part of the body. Primary malignant tumors of bone are most often sarcomatous.

Secondary bone tumors appear after a primary cancer has metastasized from some other location, such as the breast or prostate gland. Secondary or metastatic tumors of bone are most often of a carcinomatous nature.

Tumors of all types, benign and malignant, primary and secondary, may occur in the vertebrae. Most tumors of the vertebrae are prone to be malignant, because the vertebral bodies are made up of cancellous bone tissue which is subject to providing lodging place for metastatic growths. One major difference between benign and malignant bone tumors may be considered in the light that benign tumors do not endanger health, but malignant tumors do.

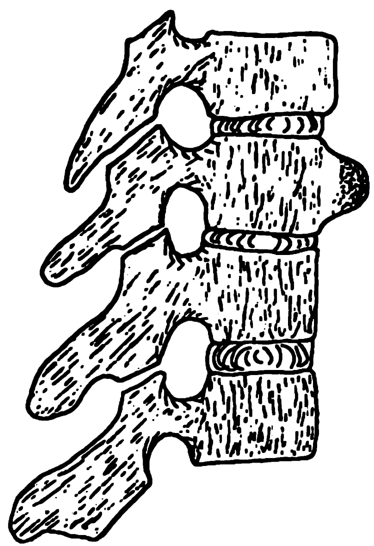


Fig. 92. Osteoma—with the typical smooth rounded appearance. This is arising from the vertebral body and is made up of spongy bone (cancellous osteoma). An osteoma may be composed of hard bone (ivory osteoma).

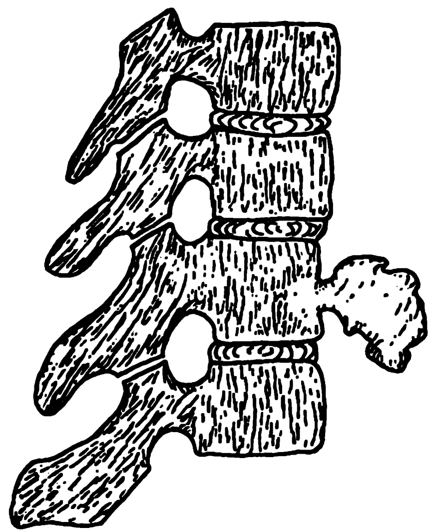


Fig. 93. Chondroma—This is a form of ecchondroma as it originated from the vertebral cartilage but has been left behind by the growth of the bone.

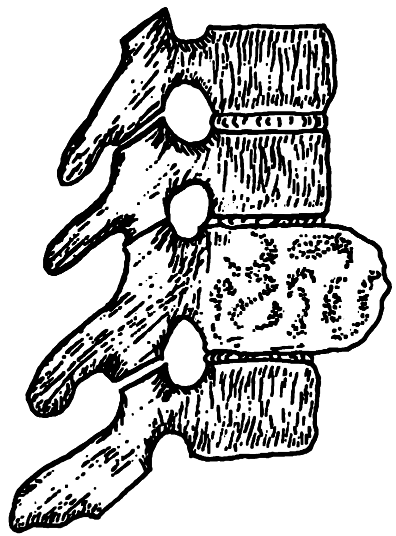


Fig. 94. Giant Cell Tumor—or Osteoclastoma. Note the thin cortex of the vertebral body containing many cystic areas similar to bubbles.

BENIGN BONE TUMORS

1. **Osteomas**—are benign tumors composed of osteoid tissue and atypical bone. They are comparatively rare, and are more common in the years from childhood to early adult life.

Osteoid osteomas are most apt to appear in the neural arches and articular processes when affecting the vertebrae, although this type of tumor is most frequently found in the shafts of the long bones such as the femur or tibia. The typical lesion observed on an x-ray film appears as a small central core of calcified material surrounded by an area of less dense bone which appears as a halo or shadow around the densely calcified center. It is often difficult to differentiate true osteomas from certain bony overgrowths due to inflammatory conditions or injuries. Among the latter are calluses which form at the site of fractures; also exostoses, and endostoses. Early in the course of a tumor the normally smooth contour of the vertebra will begin to appear blurred. Furthermore, osteomata are benign, grow slowly, rarely reach a large size, and usually stop growing after the patient reaches adult life.

The pathological picture of an osteoma shows a central core or nidus made up of a reddish nodular formation, rubbery in consistency, and surrounded by a zone of thick, hard bone. The central core is the osteoma itself. The symptoms produced by a vertebral osteoma will depend upon its location and direction of encroachment upon adjacent tissues. However, pain is rather a constant finding being located in the region of the tumor. Tenderness upon pressure is another clinical sign of importance.

2. **Fibromas**—are tumors composed of connective tissue. They may be soft or hard, according to the density of the fibrous tissue, and the amount of liquid material contained. These benign tumors are not common to the vertebral column, but when found, are usually in connection with the periosteum. They frequently undergo secondary ossification, and for this reason, are easily confused with osteoma which they may closely resemble symptomatically and spinographically.

3. **Chondroma**—this tumor is composed of cartilage, but its structure differs from that of normal cartilage in that the shapes of the cells are variable. They may not always show a cell wall, and are irregularly placed in the tumor. Chondromas are classified as:

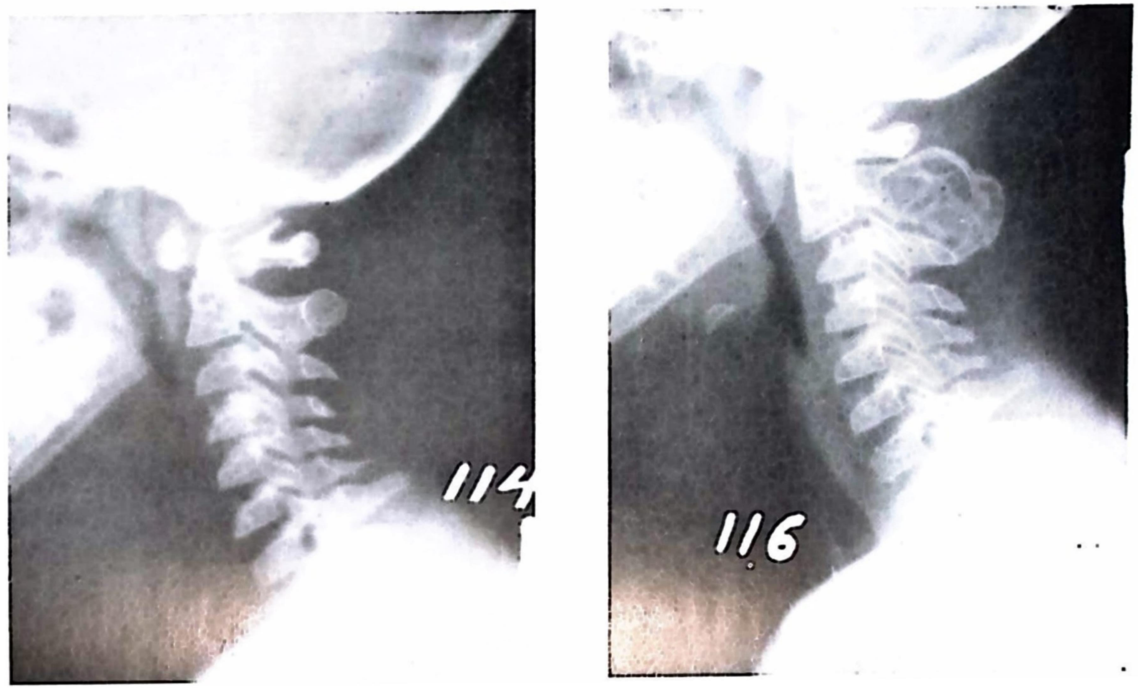


Fig. 95. Osteoclastoma. An interesting study of a case showing the development of a giant cell tumor on the axis spinous process over a period of one year.

(1) endochondroma, which arises from tissues normally containing no cartilage; and the tumor grows within the bone.

(2) ecchondroma, growing from normally existing cartilage in an outward direction from the bone.

(3) ecchondrosis, which is a massive proliferation of normal cartilage with the tumor growing outwards from a bone.

Most vertebral chondroma are of the ecchondrosis type, and usually involve the epiphyseal plates of the vertebral bodies.

Chordoma is a term applied to a form of ecchondrosis in which the tumor is made up of round, embryonic notochordal cells found in the region of the occiput, cervical vertebrae and sacrum. Frequently this type of tumor will become cancerous and will metastasize.

All forms of chondroma are hard and inelastic, and grow slowly. A frequent secondary change is that of ossification which gives rise to the difficulty in the differentiation of chondromas from osteomas. In fact, it may be assumed that an osteoma is merely an ossified chondroma. Chondroma is the commonest benign tumor of bone.

4. **Myxomas**—are composed of mucoid tissue, resembling the vitreous humor of the eyeball or Wharton's jelly of the umbilical cord. This benign tumor frequently affects the periosteum and bone marrow and appears as a soft gelatinous growth attached to the vertebral body by a stalk. Myxomas are frequently found in company with other bone tumors, and fibroma and chondroma frequently are transformed into myxoma as a result of degeneration. Myxomas have a tendency to become malignant owing to the presence of sarcomatous elements.

5. **Giant Cell Tumors—(Osteoclastomas)**

Osteoclastomas are the second most common type of bone tumors, and closely approach the frequency of osteogenic sarcomas which are malignant bone tumors. However, osteoclastomas, or giant cell tumors, are benign in their usual state, but they have a tendency to become cancerous. They most frequently affect the lower jaw where they are known as epulides, but they may occur in the ends of long bones.

The vertebral column is a frequent site of giant cell tumors. The growth usually arises from the periosteum and forms a firm, slowly enlarging mass. When it arises in the medullary portion of the bone it appears as a soft, jelly-like growth with a dark red color. In the latter type, the growth tends to press upon the cortex of the bone until it becomes a thin shell of bone which is easily fractured. Giant cell tumors should not be confused with certain highly malignant sarcomas that contain giant cells. The giant cells of an osteoclastoma are of the foreign body type, whereas those of an osteosarcoma are true tumor cells. Microscopically, the giant cell tumor is composed of three types of cells, (1) spindle-shaped cells; (2) round cells; (3) giant cells. The giant cells are osteoclastic in type, and are large multinucleated cells. They possess many small oval nuclei located near the center of the cells. Spinographic observation of an osteoclastoma shows a multicystic tumor sharply outlined in contrast to the vertebral body, and which appears similar to a nest or collection of large, clear bubbles. The cortex of the bone overlying the tumor may be very thin, or it may have disappeared entirely.

The subjective symptoms of a vertebral osteoclastoma will, of course, depend upon its location and direction of growth. If it grows inwardly toward the neural canal, it may compress the spinal cord with consequent clinical manifestations of nerve pressure. Otherwise, the symptoms of pain and tenderness upon pressure may be the only outward indication of tumor. Like most benign tumors of bone, it develops more often in children and young adults than in people of middle or old age.

MALIGNANT BONE TUMORS

Malignant bone tumors may be considered as of two types:

(1) **Primary malignant tumors,** and (2) **Metastatic tumors of bone.**

The primary malignant tumors of bone include **Osteogenic sarcoma, Ewing's tumor, myeloma,** and **extraperiosteal sarcoma.** However, extraperiosteal sarcoma cannot be considered a true bone tumor because it arises from the periosteum and does not actually form bone tissue tumors. The majority of bone tumors will present a past history of trauma to the bone involved, although fractures are but infrequently followed by tumor formation at the area of break and healing.

The important metastatic tumors of bone are carcinomas and hypernephromas. Most metastatic carcinomas arise from the breast, thyroid gland, stomach, and genitourinary organs, especially the prostate glands.

These malignant growths tend to metastasize to the vertebrae, ribs, sternum, skull, pelvis, humerus, and femur, where they attack the cancellous part of the bone.

Hypernephromas often metastasize to the skull. Because of the frequency of involvement of the bone marrow, such carcinomas often lead to severe anemia. A spontaneous fracture of a bone in an elderly man often arouses suspicion of a metastatic bone tumor arising from prostatic malignancy.

1. **Osteogenic Sarcoma**—is the most frequent type of bone tumor. It is a primary malignancy with an osteogenic background indicating that it develops first in bone tissue. The tumor arises from the embryonic bone-forming mesenchyme, and is composed mainly of osteoid tissue and bone tissue.

Osteogenic sarcoma occurs most frequently between the ages of 15 to 30 years, and is more common in the male. It is seldom seen after 50 years of age, except in those cases with Paget's disease. The most frequent site of tumor formation is in the long bones, particularly in the knee region, with 70% of all sarcomas being confined to the lower extremities. However, such tumors do arise in the spinal column, or the innominate bones, although infrequently.

The typical osteogenic sarcoma first appears in the cancellous bone tissue, then it gradually erodes the overlying compact bone and periosteum, to finally protrude free into the adjacent soft tissues. The development of the periosteum accounts for the initial symptom of pain over the affected area.

The sarcoma is often a smooth, bulky, vascular mass, regular in outline, and enclosed in a thin capsule. The resemblance to flesh is the reason for the name, sarcoma. An osteogenic sarcoma is hard in consistency and pale on cross section. It is noticeably deficient in intercellular substance compared with the number of embryonic bone cells, or osteoblasts which vary in size and shape, are nucleated, and are usually without a limiting membrane. When these growths are widespread and multiple, the condition is called **sarcomatosis**. Sarcomata in general may be classified into

three groups according to the shape of the cells; (1) the round-celled type; (2) the spindle-celled type, and (3) the giant-celled, or myeloid type.

(1) The **round-celled sarcomas** are soft, grow very rapidly, have an abundant blood supply, and may pulsate. They metastasize early because of the small size of the cells. This type of sarcoma is most frequent in the lymphatic glands, and other lymphoid tissues.

(2) **Spindle-celled sarcoma** is made up of small or large spindle cells frequently arranged in bundles, with a pronounced fibrous appearance, hence the term (fibrosarcoma). These growths usually originate in dense connective tissues, such as periosteum, fascia, and tendons.

(3) The **giant-celled sarcoma** consists of multinucleated giant cells, and lesser amounts of round cells. It is most frequently found in bone tissue, and appears as a soft, dark red, tumorous mass which contains many giant cells. It is very vascular, and usually free of pain, although its growth may produce a pressure necrosis of the adjacent compact bone which so weakens it that fracture is frequently the first clinical symptom. A giant-cell sarcoma should not be confused with the benign giant-celled tumors of bone. The type of giant cell in an osteogenic sarcoma is an **osteoblast**, whereas the giant cell of the osteoclastoma is an **osteoclast** which is the major difference between these otherwise similar bone tumors. Obviously, differentiation must be made by histological examination.

Some osteogenic sarcomas show an overdevelopment of bone tissue, or osteogenesis, and are variously referred to as osteoblastic sarcoma, osteoblastoma, and sclerosing osteogenic sarcoma. Other osteogenic sarcomas exhibit bone destruction, or osteolysis, as the predominating feature and are known as osteolytic sarcoma, telangietic sarcoma, malignant bone aneurysm, and malignant bone cyst.

All osteogenic sarcomas are subdivided on the basis of location in regard to the bone involved, and are known as **medullary, periosteal, subperiosteal, parosteal,** and **capsular.**

2. Ewing's Sarcoma (Endothelioma of Bone)

This neoplasm is also known as **Ewing's tumor, endothelial myeloma, angio-endothelioma of bone,** and **hemendothelioma of**

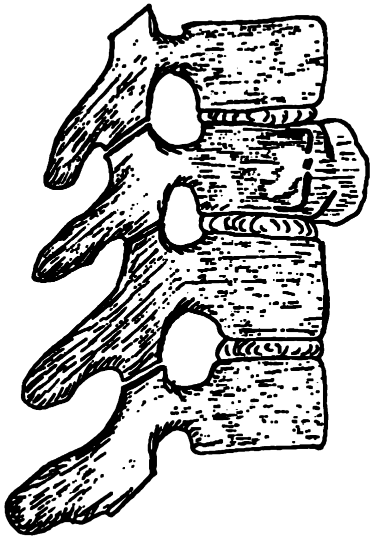


Fig. 96. Osteogenic Sarcoma—typical destruction of the crowded out periosteum with new bone formed beneath it.

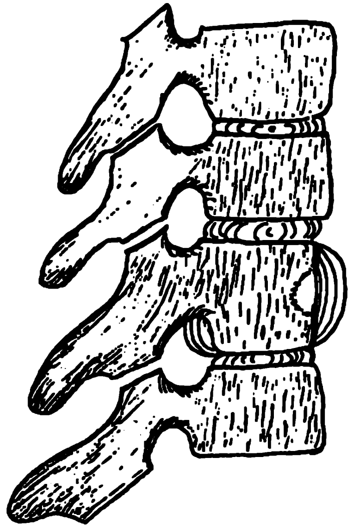


Fig. 97. Ewing's Sarcoma showing central area of destruction with new laminae of bone giving an "onion-peel" appearance.

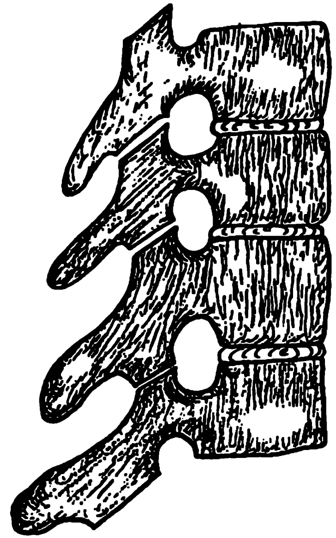


Fig. 98. Multiple Myelomas showing typical punched-out rarified areas of the involved vertebrae.

bone. It is a primarily malignant tumor of bone, usually arising as a central tumor in long bones, and is now osteogenic. The tumor is composed of sheets of young reticular cells with some endothelia cells also present. These cells show little cytoplasm, but their nuclei are large and fairly uniform. There is but little intercellular material. It is assumed that the bulk of the tumor arises from the bone marrow, originating from the vascular endothelium. It is considered the second most commonly encountered malignant bone tumor. Although Ewing's sarcoma is generally found in the shaft of a long bone, it is occasionally to be seen in the vertebrae. It is seen mostly in males between the ages of five to thirty, and often follows trauma to the involved area. The initial symptom is intermittent pain which gradually becomes constant. A swelling appears which contains a soft, pus-like material. The tumor grows rapidly so that the marrow cavity is widened and the bone is destroyed as far out as the periosteum, but this destructive process may be followed by formation of some new bone at the periphery. The shaft of the bone may show longitudinal striations as if the lesion had separated the shaft into a series of laminations.

The tumor is soft in consistency, has the appearance of a red jelly, and as it enlarges tends to invade the soft tissues adjacent to the involved bone. Ewing's tumor has a tendency to disappear under X-ray therapy, but the ultimate prognosis is poor as recurrences usually follow within two to five years.

Spinal involvement with Ewing's tumor follows the usual pattern of local pain, swelling, and bone destruction visible on the spinograph. Because of the similarity of appearance of Ewing's sarcoma of the vertebrae and that of osteomyelitis or periostitis, the only accurate diagnostic approach is the biopsy.

This tumor frequently produces neurologic symptoms when invading the spinal column by virtue of its compression of adjacent nervous tissue. The more common symptoms of this type include girdle-pain, numbness, loss of bladder control, and partial or complete paraplegia.

3. Multiple Myelomas (Kahler's Disease)

Multiple myelomas are primary non-osteogenic, malignant tumors which arise from a single cell type in the bone marrow.

Four main varieties of myelomas are recognized, depending upon the predominant type of marrow cell; the plasma cell mye-

loma, erythroblastic myeloma, myelocytic myeloma, and lymphocytic myeloma. In spite of the cell type present, all myelomas present the same gross pathologic changes and clinical course. The plasma cell myeloma is the most frequent type observed. Obviously, the biopsy is the only accurate method of determining the cell type of myeloma. About 80% of the cases of Kahler's disease occur after the age of 40, and it is twice as common in males as in females. In the early stages of the disease, the pathology is usually confined to those bones which contain a large amount of red marrow in the adult, such as the sternum, the jaw, the ribs, the pelvis, the skull, and the spinal column. In the later stages, the viscera, such as the kidneys, spleen, liver, and lymph nodes may be affected. An outstanding feature of the disease is its tendency to appear simultaneously in many different bones.

The typical clinical picture of multiple myelomas shows a diffuse osteoporosis, or areas of bone destruction, often resulting in severe pain and pathologic fractures. The bones become thin and bend, producing kyphosis or fracture.

The blood findings are typical in that anemia is common, myelocytes may be found in the blood of the liver and the spleen, and the calcium content of the blood is increased. The Bence-Jones protein body is found in the urine, and hyperproteinemia with reversal of the albumin-globulin ratio is a common laboratory finding. There is a great increase in the number of cells resembling immature plasmocytes in the bone marrow.

The tumors vary in size from that of a pea to that of an orange, are sharply circumscribed in contrast to Ewing's tumor and are usually dark red in color. There is no new bone formation, but rather, only destruction of the adjacent bone, periosteum and epiphyses. The cortex of the bone is thinned and the marrow cavity is expanded, being filled as it is with the tumorous matter. X-rays show a moth-eaten appearance, beginning in the medulla and involving all portions of the bone. Many patients may exhibit a temporary reduction of the tumors after intensive radiation, but the prognosis is poor, as the patients with myelomas ultimately die of exhaustion in two to five years.

Multiple myelomas are frequent in the spinal column with the lumbar and sacral regions being the most common sites. The outstanding feature is pain, which may disappear for several months after the initial attack, only to recur more severely, and as the disease progresses, the pain is constant.

Neurological complications of spinal column myelomas are quite common, and are usually due to impingement on the spinal cord or nerve roots, either by the tumor itself, or by the misalignments resulting from vertebral fractures. The more common symptoms of such nerve pressure include hemiplegia, paraplegia, loss of bladder control, and muscular weakness.

The X-ray manifestations of myeloma include the punched-out, circumscribed, rarified areas in the involved vertebrae, or other bones. In flat bones, the expanding tumor may press the overlying bone outward so that it has a hollowed-out appearance.

In the early stages of spinal column myelomas, the affected vertebral bodies may show a wide variety of abnormal forms ranging from osteoporotic lesions to bulging and compression fractures, and finally destruction and collapse of the vertebrae involved. The destructive process may be so extensive that but slight remnants of the vertebrae may be seen on spinographic films.

METASTATIC TUMORS OF BONE

1. Carcinoma of Bone

This neoplastic metastatic disease is a common malignancy of the vertebral column. It metastasizes from various viscera of the body and forms a secondary bone involvement. The spreading process is accomplished through the lymphatic channels or by way of the hematogenous routes of the systemic circulation or the venous vertebral plexus. It has been known to invade the vertebral column directly from a tumor growing in close proximity to the spine.

Carcinoma of bone is frequently described as osteoplastic with increased bony density, or osteoclastic accompanied by demineralization and bone destruction. Often both types are present in the same disease process of a single bone. However, the more common type is the osteoclastic, which not only decreases the mineral content of the affected bone, but also becomes so filled with closely packed cells that the blood supply is seriously impaired and necrosis of the bone takes place.

The outstanding subjective symptom of vertebral carcinoma is pain which is due to pressure on the sensitive periosteum by the expanding tumor. Also, pressure on the spinal cord or nerve roots may cause pain along with other symptoms of spinal cord

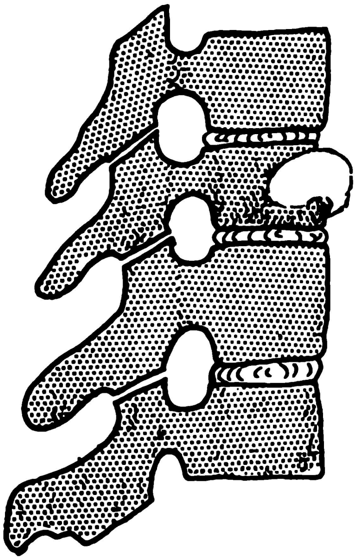


Fig. 99. Carcinoma of bone showing the decreased bone density indicative of osteoclastic carcinoma.

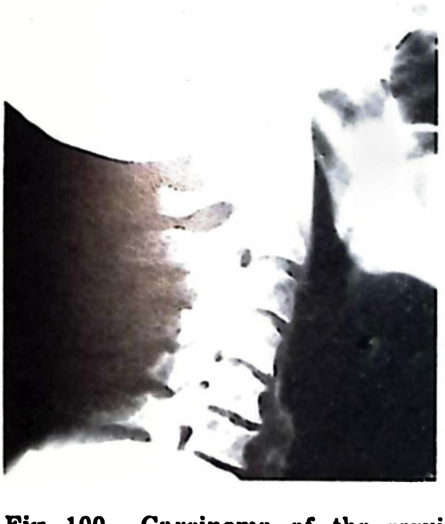


Fig. 100. Carcinoma of the cervical spinous processes. This metastasized from the prostate gland.

Fig. 101. Severe lumbar hypernephromata showing extensive bone destruction.

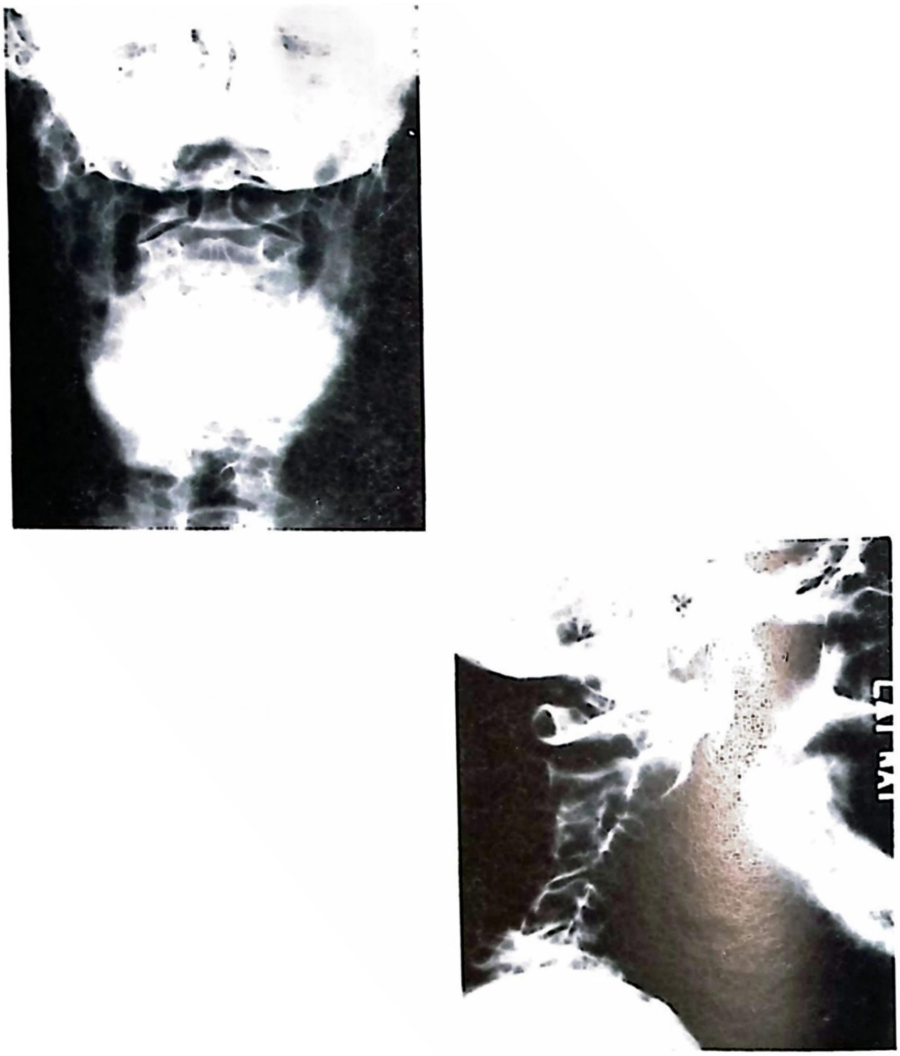


Fig. 102. Osteoplastic carcinoma of the mandible seen in A. to P. and lateral views. Note the increased density of the bone in contrast to the decreased density seen in osteoclastic carcinoma, Fig. 100.

compression. In some few cases there may be extensive destruction of the involved vertebra with no symptoms whatever.

Spinographic analysis of a vertebra showing a metastatic tumor usually discloses a shadow of decreased density indicative of bone destruction. The bone tissue shows a spotty appearance because of several small decalcified areas, but the overall shape of the vertebra may not be changed until late in the disease when most of the vertebral body may collapse. As more of the bone is invaded by the progressive metastatic growths the vertebra becomes distorted due to structural weakness, and it may appear flattened; also, erosive loss of one lateral half of the body may be apparent. Not only is the vertebral body a frequent location of carcinoma, but the laminae, spinous process, and transverses also are involved. When such growths appear in the neural arches, they may produce symptoms much like a ruptured intervertebral disc with which they are sometimes confused. Microscopic examination of the tumor is necessary to clearly differentiate it from other growths affecting bones in general and the spinal column in particular.

2. Hypernephroma of Bone

Secondary hypernephromata are very malignant metastatic bone tumors and affect the vertebrae, ribs, skull, femur, pelvis, humerus, scapula, jaw, and metatarpals. The term hypernephroma is now being replaced by "clear cell carcinoma" which is a carcinoma composed of large polyhedral, epithelial cells with clear cytoplasm. It is most commonly seen in the kidney, but may also arise in the thyroid, suprarenal, or ovary.

When attacking the spinal column, it runs a clinical course similar to that of carcinoma, only the symptoms and findings are more exaggerated. After the onset of clear cell carcinoma, the average duration of life is two to three years. The rapid spread of the disease, the profound symptoms, and the microscopic picture of the carcinoma with its clear cells, all point toward this malignancy.

BLOOD CYSTS AND TUMORS OF THE VERTEBRAL COLUMN

1. Aneurysmal Bone Cysts

An aneurysm is the dilation of an artery forming a sac filled with coagulated blood or serum. The usual etiological fac-

tors include trauma, and a weak point in the walls of an artery due to syphilis or sudden strain or injury.

The vertebral column is a rather common site for this lesion, possibly because of the frequency of spinal trauma. A typical aneurysmal bone cyst is generally a single, circumscribed, expanded fibrous tissue cyst showing great numbers of dilated blood vessels. The normal cancellous bone tissue is replaced by fibrovascular tissue, with many large dilated blood vessels and spaces.

Spinographic analysis of vertebral aneurysmal bone cysts reveals bulging of the involved bone with a thin cortex of bone overlying the cyst, and an area of bone destruction corresponding to the location of the cyst.

The symptoms of such a lesion include pain over the involved area, signs of compression of the spinal cord or nerve roots, and if the cyst is located near the skin surface, and is extruding from the vertebra into surrounding tissues, an expansile pulsation or bruit may be elicited.

2. Hemangiomas or Blood Tumors

An hemangioma is a tumor composed of blood vessels, and it occurs as a capillary hemongioma consisting of a network of capillaries, or as a cavernous hemangioma consisting of large communicating blood spaces. The most common site of capillary hemangiomas is the skin, where they are spoken of as "birthmarks", "strawberry marks", or "port wine stains".

The spinal column is not an infrequent location of hemangiomas, and thoracic and lumbar vertebrae show these tumors more frequently than do other areas of the spine. The vertebral bodies are most often affected, and the dark red growths, varying in size from a small pea to lesions involving most of the vertebra, cause destruction of the vertebral body. Many of the cancellous tissues of the vertebral framework are destroyed, and those that are left form thick, vertically positioned, parallel ridges which are easily seen on spinographs.

The presence of hemangiomas of the vertabral column may be without any symptoms except the typical bone changes seen in spinal X-rays. However, these tumors tend to slowly increase

in size, and eventually may compress the spinal cord to produce local pain, tenderness, and finally, paraplegia. The cord compression is due to ballooning of the affected vertebrae which encroach upon the neural canal and impinge the cord.

Oftentimes, a red "birth mark" will be noted on the skin overlying the vertebra within which a blood tumor is developing.

Vertebral hemangiomas occasionally become sarcomatous. Detection of a suspected case of vertebral hemangioma is essentially based upon the X-ray showing a series of vertebral, parallel, dense striations in the cancellous bone of the vertebral body.

Chapter 15

RUPTURE OF THE INTERVERTEBRAL DISC

Rupture of the intervertebral disc is known variously as herniation of the intervertebral disc, herniation of the nucleus pulposus, protrusion of the disc, and ruptured disc. The normal disc performs a vital function in the functioning of the spinal column by acting as a shock absorber. In addition, the disc is essential to the movements and weight-bearing of the spine. A healthy intervertebral disc is an extremely strong and tough structure admirably designed for the part it plays in spinal mechanics. Disc trouble may occur when the outer covering, annulus fibrosus, is weakened.

The process of degeneration of the annulus is a slow, gradual change in most cases, but finally it becomes so weakened that compression of the central nucleus pulposus breaks through the annulus walls and the nucleus protrudes or is ruptured. When the annulus tears, the nucleus bulges through the opening and in most cases it protrudes into the neural canal. The reason for this seems to be that the annulus is weakest at its posterior margin which lies directly in front of the neural canal being separated from it only by the posterior longitudinal spinal ligament.

The forcing of the nucleus out of its normal position in the disc brings about a collapse of the weight-sustaining part of the discs so that the two adjacent vertebrae are brought much closer together. This condition of vertebral proximity may cause pressure upon the spinal nerves emitting at the local intervertebral foramina. Another cause for the usual nerve pressure is the compression of the spinal cord by the bulging of the nucleus pulposus into the neural canal.

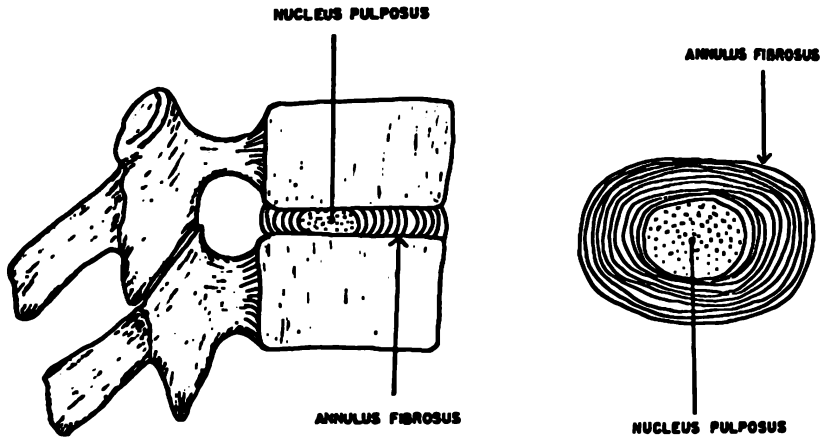


Fig. 103. The normal intervertebral disc seen in horizontal and sagittal sections.

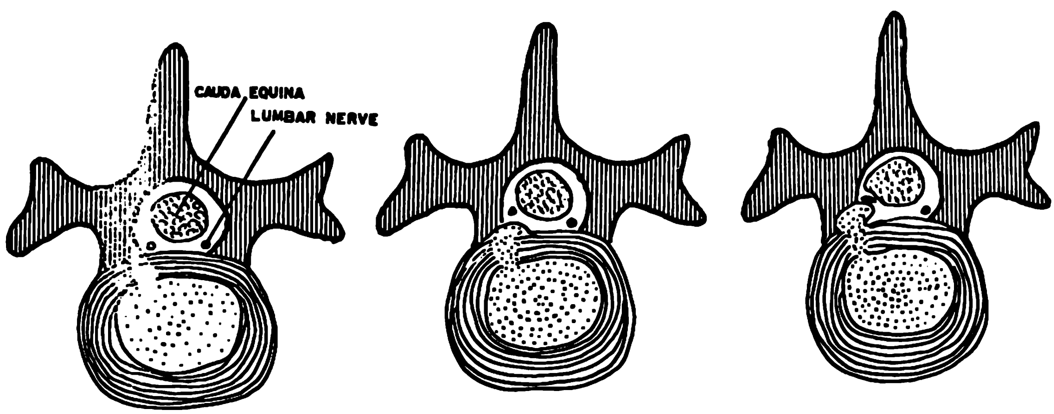


Fig. 104. Stages of rupture of an intervertebral disc. The picture to the left shows a slight weakening of the annulus fibrous. In the middle picture the nucleus pulposis is escaping backwards into the neural canal. The illustration on the right shows compression of a lumbar nerve root. (Herniation of the nucleus pulposus into the soft bone of the verebra is known as Schmorl's lesion.)

More than 90% of all cases of ruptured discs occur in the lower lumbar region, involving the discs between the fourth and fifth lumbar and the sacrum.

LUMBAR INTERVERTERBRAL DISC HERNIATIONS

The outstanding clinical feature of lumbar ruptured disc is low back pain and sciatica. However, the physical findings in lumbar disc rupture are variable. Pain is usually present in early cases, but objective changes may not be demonstrable immediately. In advanced cases the patient's posture may suggest a structural deformity of the spine. About 75% of all cases show a unilateral sciatica, probably the result of compression of the nerve roots on one side and not the other. The sciatic pain, when acute, causes a lateral bending of the lumbar spine, a so-called "sciatic scoliosis". Usually the bending is away from the side involved. Another common finding is the tendency to fix the lumbar spine anteriorly and hold it rigidly in this position so that the back appears flat. Both these deformities persist on motion as they are attempts to lessen the pain which may be exaggerated by coughing, sneezing, or straining. It is often impossible for the patient to be on the back. Associated with the sciatic pain is numbness along the lateral aspect of the lower leg and foot, with intense pain on stooping forward, and weakness in the leg. On examination, straight leg raising more than 30 degrees from the table is impossible—"Lasegue's sign." The knee jerk is present, but the ankle jerk on the affected side is usually absent. There is localized pain and tenderness in the lower lumbar area, and deep pressure at this region will bring on increased pain in the thigh and leg. As the sciatica becomes chronic there is noticeable atrophy of the calf and thigh.

Compression of the jugular veins by the examiner will also increase the pain of sciatica as long as the pressure is maintained—"Queckenstadt's sign." A great deal of study has been done to help locate the exact point of nerve pressure in cases of lumbar disc herniation by observing the neurologic findings associated with disc rupture at the various lumbar levels. For example, rupture of the disc between the fifth lumbar and sacrum is supposed to cause pain in the back of the thigh, calf, and ankle; tenderness over the sciatic nerve trunk, weakness of the gastrocnemius muscle group, and atrophy of the calf. However, it is

now realized that such localization of the lesion by neurologic findings is not practical nor constant, due to the complexity and arrangement of the nerve roots in the neural canal as well as the great number of possible directions of pressure from the ruptured nucleus pulposus. In fact, all or part of the herniated nucleus may migrate within the neural canal to produce neurologic symptoms far removed from lesions usually associated with a particular level of the spine. There is no doubt that nerve compression of this type can cause serious damage to the nervous structures, ranging from deformity and atrophy of the nerve cells to scar tissue formation in the cord or nerves.

THORACIC INTERVERTEBRAL DISC HERNIATIONS

The thoracic spine is an uncommon location of the ruptured disc with most of such lesions being located between the fourth to the twelfth thoracic levels. The symptoms associated with thoracic herniated discs are variable and depend upon the location of the herniation and the degree of comparison of the nerve roots or of the spinal cord.

In the upper thoracic regions the symptoms may approximate those seen in rupture of the lower cervical discs; in the mid-dorsal region the predominant symptom is nerve root pain, and when the lesion occurs in the lower dorsal region there may be pain and functional defects of the abdominal viscera, the pelvic region and about the waist line. Complete paralysis below the level of the lesion may occur, and sphincter control may be lost in certain severe cases of spinal cord compression.

CERVICAL INTERVERTEBRAL DISC HERNIATIONS

The most common site for ruptured discs of the cervical region is between the fifth and sixth and the sixth and seventh cervical vertebrae. Lesions at these levels may produce a variety of symptoms depending upon the nervous structures subjected to pressure and interference, but the symptoms may be considered in two main groups; mid-line, and lateral.

If the herniated disc is in the mid-line, the signs of spinal cord compression are produced. The physical findings include

weakness and spasticity of the lower extremities, hyperactive reflexes, sensory disturbances and sphincter difficulties.

Lateral herniation of the disc may cause pressure upon the nerve roots with subsequent local pain and motor weakness. Since the nerve roots of the lower cervical region help make up the brachial plexus, many of the symptoms of motor and sensory disturbances will involve the upper arm. In cases of ruptured disc between the fifth and sixth cervical vertebrae the pain is located over the top of the shoulder and lateral aspect of the arm, the biceps muscle is weakened, and atrophy of the biceps may occur. A disc lesion between the sixth and seventh cervical vertebrae may cause pain in the posterior aspect of the arm with weakness and atrophy of the triceps muscle.

The patient with cervical disc herniation tends to carry his head in slight forward flexion since extension of the neck increases the pain. Lateral bending of the head toward the side of the lesion increases the pain, and lateral bending away from the side of the lesion decreases it. Pressing downward upon the head usually greatly increases the pain. Compression of the jugular veins will also increase the pain, as will the acts of coughing, sneezing or straining.

THE DIAGNOSIS OF RUPTURED INTERVERTEBRAL DISC

The determination of ruptured intervertebral disc may be based upon a series of findings which when properly evaluated may be strongly suggestive of this lesion. That such diagnosis is subject to many inaccuracies is obvious in light of the great number of possible spinal conditions which closely simulate the clinical picture of a ruptured disc.

The more important of the procedures used to identify the disc lesion may be briefly considered as follows:

1. Case history—with many cases having a history of trauma to the spinal column, either the immediate or recent past.

2. Clinical symptoms of spinal cord or nerve root compression.

3. Cerebrospinal fluid changes showing increased fluid pressure and elevation of the protein content.
4. Pantopaque myelography in which this contrast medium is injected into the subarachnoid space in an effort to locate the point of herniation of the disc. Iodized oil and air is also used for the same purpose. X-rays are then taken to observe a defect in the subarachnoid space.
5. Plain X-ray films are made of the suspected vertebral region and any significant narrowing of the vertebral interspaces is noted.

THE CHIROPRACTOR AND THE RUPTURED INTERVERTEBRAL DISC

For many years the Chiropractor has been successfully dealing with nerve interference and its attendant disease. Many of his patients were suffering from symptoms directly attributable to injuries of the spinal column, and today the Chiropractor is still routinely reducing this nerve interference associated with that large group of symptoms known as the ruptured disc syndromes.

That chiropractic care in such cases is simple, direct, and outstandingly efficient, is shown by countless thousands of patients who are now free of symptoms that had been diagnosed or would have been diagnosed as a ruptured intervertebral disc. It is difficult to believe that all these cases were suffering from compression of the spinal cord or nerve roots as a result of a herniated disc. If such were the case, it is again beyond belief that adaptation to the direct pressure upon the delicate nervous structures could be affected in so many cases who became symptom-free after chiropractic care. Obviously, the answer lies in mistaken diagnosis of the condition. It is known that even the most elaborate and extensive diagnostic procedures frequently fail to identify a ruptured intervertebral disc as the causative factor of symptoms common to the lesion. In view of this fact, it would seem that there is a pronounced tendency to label any case of obvious nerve pressure a "ruptured disc case."

Without doubt, there are some few cases of true ruptured intervertebral discs which are beyond the adaptative and re-

cuperative powers of the body and such cases may well require outside assistance to remove the pressure upon the nervous tissues. The overwhelming majority of so-called ruptured disc cases, however, fall into the category of those in which relief may be expected under chiropractic care.

The patient who has been told he has a ruptured intervertebral disc is indeed in a dilemma. Should he consult the services of a Chiropractor under whose care he can reasonably expect rapid and lasting results with a minimum of financial outlay and dislocation of his daily living? Or should he go through many and varied tests and procedures, some of which are not without grave danger, and ultimately be burdened by severe economic loss and no surety of complete relief of symptoms? Such a decision should not be difficult to make.

Chapter 16

INJURIES OF THE SPINE

Sprains, fractures, dislocations, and fracture-dislocations are common injuries of the spine, but vertebral subluxations are by far the most frequent of all spinal injuries.

The most frequent causes of spinal lesions are automobile accidents, industrial accidents, athletic injuries—in fact, any fall, twist, or violent shock may precipitate spinal traumatic changes.

1. A **Sprain** is a wrenching or tearing apart of a joint, producing a stretching or laceration of the ligaments without a dislocation or an actual break. The symptoms are pain, tenderness, and rigidity, and since these closely parallel the signs of a simple fracture, the only accurate means of differentiation is by means of the X-ray. In a strain of the back, such as produced by heavy lifting, the lesion is in the muscles, not the joints.

2. A **Fracture** is the breaking of a bone. A **Simple fracture** is one in which there is no communication with the outside, and this type is frequently seen in vertebral injuries as fractures of the spinous process, transverse processes, or laminae. A **Compression fracture** is one in which a surface of a bone is driven towards another bony surface and is commonly found in the vertebral bodies.

Fracture of the spine is caused by direct, or much more frequently by indirect violence. Direct violence usually fractures the vertebra at the point struck, and the vertebral arches are most likely to be involved. Oftentimes a fragment of bone will be driven into, or against the spinal cord. The spinous processes, transverse processes and laminae are broken by direct violence. Compression fractures are frequently the result of indirect violence as from a blow on top of the head, diving into shallow water, falling from

Fig. 105. Fracture-dislocation of the axis.

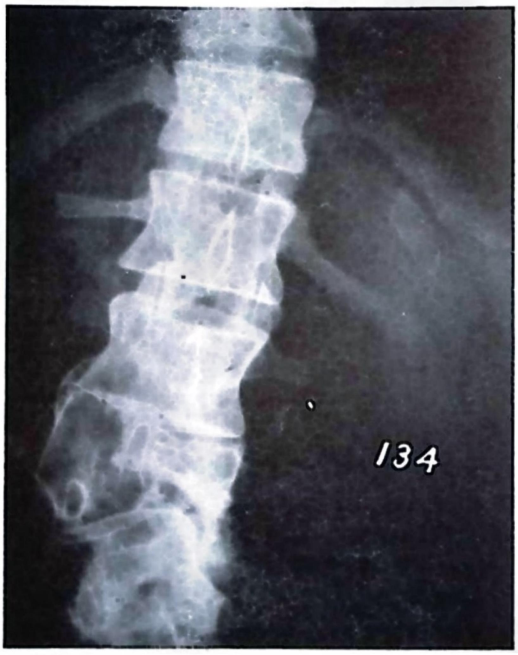


Fig. 106. Compression fractures of 3rd and 4th lumbar vertebrae.

a height on the feet or buttocks, or if the person is doubled up suddenly so that hyperflexion of the spine takes place. The vertebral column generally fractures at the junction of a freely movable with a comparatively fixed portion, as in the cervico-dorsal or dorso-lumbar region.

The symptoms of fracture of the spine are (1) **Shock**, either slight or severe; (2) **Local evidence of fracture**, such as tenderness, pain, swelling, and usually deformity; and (3) **Interference with the functions of the spinal cord** due to compression, concussion, or contusion. According to the degree of cord involvement there may be more or less complete paralysis, anesthesia below the injury, absent reflexes and trophic changes. If no displacement of the fractured part has taken place there may be an absence of cord symptoms; and, on the other hand, such symptoms coming on after a short interval may be due to a vertebral subluxation, edema of the cord, or meningeal hemorrhage.

Any fracture of the spinal column showing complete anesthesia and total paralysis has a serious prognosis, and the higher the lesion the worse the outlook.

Fracture of the upper cervical region may cause immediate death from shock or interference with respiration. Death may occur after about a week from suffocation with mucous in lower cervical fractures; or death may be delayed for weeks or months, only to come from sepsis and exhaustion resulting from pyonephrosis, cystitis, or bed sores. However, even with a completely sectioned cord at the dorsal or lumbar levels, life may continue for many years.

It should be borne in mind that many cases showing definite vertebral fracture with these serious symptoms supposedly due to compression or section of the cord, are in reality exhibiting pressure symptoms from a vertebral subluxation accompanying the fracture. A Chiropractic adjustment of the involved vertebra should be given only after careful X-ray studies of the fractured spinal segment.

3. A **Dislocation** is the displacement of one or more bones of a joint from the original position. Dislocations of the vertebrae without fracture are relatively rare because of the tremendous strength and resistance of the spinal muscles and ligaments. An external concussion of forces sufficiently great to displace a vertebra is more likely to cause fracture than dislocation.

The greatest number of spinal dislocations is observed in the cervical region. The varieties include atlas on axis (most common), occiput on atlas, which is rare and generally fatal, and dislocations between the lower cervical vertebrae.

The usual cervical dislocation is caused by violent hyperflexion of the neck with the articular processes of the upper vertebra passing to the front of those of the lower vertebra. This type is known as a **complete bilateral anterior dislocation.**

Hyperextension of the cervical spine may cause **bilateral posterior dislocation,** and **unilateral dislocation** may come about from violent lateral flexion and rotation of the head towards the shoulder. In anterior dislocations of the cervical vertebrae the head is displaced forward and bends toward the chest. In posterior dislocations the head is displaced backwards and the face turned upwards. In unilateral dislocations the head is bent away from the side of joint involvement.

Incomplete dislocations are essentially a form of vertebral subluxation. The ligaments and intervertebral discs are torn, and the spinal cord may be compressed or the spinal nerve roots may be stretched or torn.

Proper analysis of any vertebral dislocation must, of course, depend upon careful X-ray studies by the Chiropractor. A history of violence to the spinal column should be regarded with suspicion, particularly if post-traumatic muscle spasm is present.

4. **A fracture dislocation** is one in which a fracture accompanies the dislocation. Most vertebral dislocations also show a fracture of the involved structures because of the aforementioned reasons of spinal tissue strength resisting traumatic concussions of force.

5. **Concussion of the spinal cord** is caused by falls or blows which shake or jar the cord. No fractures or dislocations are present. The cord shows no pathological changes; but, occasionally minute hemorrhages in the cord substance may be observed, and then the condition becomes a **contusion of the spinal cord.**

In cord concussion, the symptoms are those of shock, and it is usual for some degree of sensory and motor impairment to appear for a few hours or days. If the symptoms are severe or persist, the condition is probably one of hemorrhage or compression of the spinal cord. Frequently these cases of cord concussion

will rapidly develop a neurasthenia or an hysteria known as traumatic neurasthenia and trauma hysteria respectively.

Cases of spinal cord concussion are essentially chiropractic cases as there is no doubt that they are victims of nerve interference resulting from vertebral subluxations. In fact, a diagnosis of concussion of the spinal cord should be interpreted by the Chiropractor as meaning a subluxation.

6. Kummel's Disease

This condition is progressive collapse of a vertebral body following a spinal injury. The thoracic and lumbar vertebrae are most frequently involved, and if examined immediately after injury, may show no abnormal changes. However, the collapse becomes apparent after a few months and is probably a decalcification or bone necrosis resulting from interference to the vertebral blood supply. Kummel's disease also may eventually show calcification of the adjacent intervertebral disc as well as the characteristic wedging of the vertebral body.

EXAMINATION OF THE SPINAL INJURY PATIENT

The examination of a person immediately after injury to the spinal column should be done with care and thoroughness. Disturb the patient as little as possible. If fracture or fracture-dislocation of any spinal region is suspected, the prime concern is to prevent injury to the spinal cord. Great care should be exercised in moving such a patient, and particularly if the cervical region seems to be injured. An assistant should apply gentle traction on the head whenever the patient is to be moved; and the patient must not be allowed to flex the neck, as in drinking a glass of water. Any rotation, flexion or extension of the spinal column should be prohibited until X-rays have shown no fracture or dislocation to exist.

There are several simple tests for spinal cord injury which can be done without endangering the patient. (1) Ask the patient to move his toes and legs. If he can do so, there is no major cord damage. If the legs are paralyzed and the patient can still move his hands, the lesion is below the cervical region. (2) If the arm function seems to be impaired, the position assumed by the patient may be an indication of the area of injury. In lesions at the level of the sixth cervical vertebra, the arms are abducted, the

elbows flexed, and the forearms pronated. If the lesion is at the seventh cervical level, the elbows are flexed, and the half closed hands rest on the anterior chest wall. If the cord has been cut at the fifth cervical level, both arms will show a flaccid paralysis. Section of the spinal cord at fourth cervical or above is usually fatal by causing phrenic nerve paralysis. (3) Loss of sensation below the point of spinal cord injury is a help in locating the point of major cord injury.

CHIROPRACTIC CARE OF SPINAL INJURIES

The modern, well trained Chiropractor is considered an authority on spinal conditions and is frequently the first person consulted when trauma to the spinal column has taken place. Any thinking practitioner would not consider adjusting a patient with a history of recent trauma until complete and careful X-ray analysis had established the extent of the spinal injury. The chiropractic approach must be based upon the findings in each individual case so there is no hard and fast rule to follow. Cases showing recent fractures or fracture-dislocations of such a nature that the concussion of forces of an adjustment might injure the spinal cord or nerves are probably best referred to the orthopedist. This does not mean, however, that such conditions have not and cannot be dealt with successfully by chiropractic care, but the decision to adjust such cases must be based upon careful study of all the possibilities involved. As a general rule, a fracture of a vertebra which shows definite strong healing union can be adjusted with no danger. Indeed, experience shows that such cases usually are in need of chiropractic care, as the trauma which caused the fracture also brought about nerve interference, and an adjustment is often followed by disappearance of neurologic symptoms and more rapid healing of the fracture.

Dislocations and their care chiropractically can be resolved according to the degree of dislocation. It is clear that a complete bilateral dislocation of a vertebra is potentially dangerous to the life and health of the patient, and because of the mechanics involved, must be considered in the field of orthopedics. However, the great majority of so-called dislocations are actually vertebral displacements which can be termed subluxations when all the requisites of a subluxation are present. What may have been diagnosed medically as a dislocation, is in actuality only a pronounced vertebral subluxation. It may be assumed that any such

vertebral subluxation may be safely adjusted. A subluxation is defined as the loss of juxtaposition of a vertebra with the one above or the one below, or both, to the extent that it occludes a foramen and interferes with the transmission of mental impulses between brain cell and tissue cell. We know that the degree of this loss of juxtaposition has no bearing upon the number or severity of the symptoms produced, but rather that such reactions depend upon the extent of nerve interference. By the same token, any spinal misalignment with attendant nerve interference becomes a subluxation if the loss of vertebral position is less than a dislocation and should be considered within the scope of chiropractic care.

CAUSES OF FRACTURES AND DISLOCATIONS OF CERVICAL SPINE

The most common causes of fractures and dislocations in the cervical region are automobile accidents, industrial accidents, and athletic injuries. Perhaps the greatest single cause of severe cervical trauma is the so called "whip-lash injury" which results from automobile collisions, either from a head-on crash or from being struck in the rear while the car is stopped. This causes a hyperflexion of the neck immediately followed by an extensor recoil. The weight of the head, and the usual muscular relaxation in such an unexpected accident, combine to whip the neck so violently that fractures and dislocations of the lower cervical vertebrae are to be expected.

Fracture of the atlas is most likely to occur when the force of a blow is directed downward upon the vertex of the skull. The concussion of force travels down through the skull to the atlas which is subjected to counterpressure from the vertebrae below; the result is that the atlas lateral masses are squeezed laterally on the occipital condyles. The anterior and posterior arches of atlas are the weakest bony parts and they are literally torn asunder with lateral displacement of the fracture fragments. Axis fractures are frequently the result of diving accidents in which the head strikes the water or the bottom, and the neck is arched laterally so that the full leverage is applied to axis. The odontoid is commonly the site of fracture in this type of injury.

In addition to trauma, dislocations of the atlanto-axial joints may result from a variety of other causes. Among the more commonly encountered of these are congenital defects of the joint

structures such as an absent odontoid process, tuberculosis or syphilis of the cervical spine with attendant destruction of joint tissues, and local inflammatory conditions such as adenitis, mastoiditis, and torticollis, which diseases tend to distort and weaken the atlanto-axial articulation.

CAUSES OF FRACTURES AND DISLOCATIONS OF THE THORACIC SPINE

Fractures of the thoracic spine may be attributed in large measure to the usual causes of spinal injuries. Sudden hyperflexion of the spinal column may so squeeze the vertebral bodies as to cause a compression fracture—the usual type found in this region. However, fractures and dislocations of the thoracic spine are relatively infrequent as compared to the other spinal regions. This may be due to the relative protection of the ribs, and the inherent stability of the thoracic region.

One particular cause of thoracic spine fractures which should be considered carefully by the Chiropractor is that of shock therapy for psychotic patients. Many patients who have been treated by the shock therapy approach have suffered thoracic fractures during the height of the convulsive reaction. Accordingly, all such cases with a history of this treatment should be carefully analysed by chiropractic X-ray procedure for the protection of both patient and doctor.

CAUSES OF FRACTURES AND DISLOCATIONS OF THE LUMBAR SPINE

Because of the heavy muscle ridge along side of the lumbar spine, direct trauma is not as important a factor in producing lumbar fractures as are the violent movements of hyperflexion or torsion. Like the thoracic spine, the lumbar spine exhibits more fractures of the compression type than it does simple fractures. Also, the pull of the adjacent muscles makes injury of the lumbar region more likely to be a combination of fracture and joint contusion. Fractures of the first lumbar and the twelfth dorsal account for nearly 80% of all spinal fractures. This is because of their mechanical function and relative freedom of motion compared to the vertebrae immediately above and below them. Most thoracic-lumbar fractures are of the compression type and result from sudden jack-knifing of the spine at this vulnerable joint. A heavy blow across the shoulders or upper part of the body caus-

ing the body to bend over sharply is often sufficient to strain these vertebrae beyond their limits of compression.

CAUSES OF FRACTURES AND DISLOCATIONS OF THE SACRUM AND COCCYX

The majority of fractures of the sacrum and coccyx are the result of direct trauma to these bones. A fall upon the buttocks, or a heavy blow across this region may be sufficient to cause a break. The outstanding symptom of sacral or coccygeal fracture is severe pain which is aggravated by walking or standing, and is not materially reduced by lying down. Various motor and sensory disturbances of the lower extremities may appear as a result of injury to the cauda equina. Sacral fractures may injure the sacral plexus causing paralysis of the bladder and rectum. Dislocations of the sacro-coccygeal joints are frequent injuries resulting from falls or blows to the buttocks area, particularly a fall in which a person lands hard in a sitting position. Difficult childbirth may displace the coccyx. The coccyx may be displaced anteriorly, posteriorly, or laterally with resultant pull upon the filum terminale which may yield neurologic manifestations. Severe pain is a common finding, and is known as coccygeal neuralgia, or coccygodynia. It is increased by walking, coughing, or defecation. Chiropractic has an enviable record in the relief of coccygodinia and certainly such care is to be preferred to the alternative of surgical amputation of the coccyx.

DISLOCATIONS OF THE SACRO-ILIAC JOINTS

The sacro-iliac joints are a frequent source of discomfort following injuries to the lower back. Many cases considered as dislocations are actually strains of the joint tissues and local muscles. For example, relaxation of the supporting ligaments occurs during the latter part of pregnancy, and it is frequently followed by sacro-iliac strain during the peurperal period.

True dislocation, or separation of the sacro-iliac joint occurs when there is fracture of the pelvis which so distorts the pelvic region that the joints between the sacrum and ilium become separated. The usual symptoms of sacro-iliac dislocation include localized pain and tenderness, increased pain upon standing, increased pain upon crossing the legs, and a positive Ely's sign. This latter sign is based upon having the patient lie prone with both feet hanging over the edge of the table, and then the pa-

tient's heel is brought up towards the buttocks while the thigh is extended. A positive reaction is the inability to bring the heel to the buttocks without the pelvis rising from the table. Another clinical symptom of sacro-iliac dislocation is a positive Trendelenburg test. In this procedure the patient stands with the back and buttocks exposed. He is then told to lift first one foot and then the other. When standing on the affected side, the gluteal fold on the sound side falls instead of rising when the sound foot is raised.

Chapter 17

CAUSES OF BACHACHE

The factors contributing to backache are so many and varied that to compile them on an individual basis is almost impossible. A list of causes of backache can be expanded to include almost every type of injury and disease. A backache is merely a symptom of disease in the body. However, four general classifications of backache may be considered on the basis of the major cause of each: (1) those caused by mechanical difficulties; (2) those caused by disease; (3) those caused by injury; and (4) psychosomatic backache.

I. BACKACHE DUE TO MECHANICAL DIFFICULTIES

1. **Postural Strain**—a common complaint in adults is chronic low backache which comes on after walking or standing or bending, and is relieved by lying down. It is frequently termed "static backache". In many of these cases, it will be found that the patient has exaggerated lordosis, protuberant abdomen, and round shoulders. Back pain occurs because of spinal distortion, and its accompanying strain on the attached muscles. Other related conditions include flatfoot, improperly fitted shoes, and visceroptosis.

2. **Occupational Strain**—is characterized by aching pain in the muscles of the upper or lower thoracic regions, as well as headaches and cervical pains. It is seen in patients whose work requires constant stooping over a work bench or desk.

3. **Pregnancy Backache**—in which the pregnant woman complains of a dull persistent ache throughout the lumbar and lower dorsal regions in the last half of her pregnancy. This results from a shift in the center of gravity with attendant strain upon the spinal muscles. Also, pelvic joint relaxation occurs

normally during pregnancy, and the abnormal mobility of the pelvic girdle permits unusual motion at the symphysis pubis and sacroiliac joints which, in turn, produce local pains.

4. **Gynecologic Backache**—is a very common symptom in cases of female disease. It is usually a diffuse aching across the sacrum, and may come from such conditions as retrodisplacement of the uterus, parametritis, prolapse of the uterus, and pelvic tumors and cysts which interfere with the sacral plexus or its branches causing pain which is generally of sciatic distribution.

5. **Spinal Deformities**—Lordosis, scoliosis, and kyphosis are all associated with constant backache, spread throughout the entire spinal region, but worse near the pelvic girdle, because of the faulty posture causing constant muscular strain. Congenital defects of the spine, such as misshapen or displaced vertebrae, and variations in the lumbosacral angle also cause backaches.

II. BACKACHE DUE TO DISEASE

The diseases that can result in pain in the back are manifold, and may be related to almost any part of the body. In the interest of simplification, these may be grouped into certain general clinical classifications:

1. **Spinal Diseases**—as a cause of backache include arthritis, tuberculosis, and osteomyelitis. Syphilis and bone tumors may cause pain in the spinal region.

2. **Nervous System Diseases**—such as neuritis, meningitis, sciatica, poliomyelitis, and encephalitis.

3. **Focal Infections**—including teeth, tonsils, or sinuses may spread toxins throughout the system which seem to localize particularly in the spine.

4. **Urogenital Diseases**—are common causes of backache. In kidney disease, the pain is usually in the lumbar region, to either side of the mid-line and referred along the course of the ureter to the bladder. It is not influenced by changes in position, and is increased by deep palpation. Backache in men is sometimes the result of infection of the prostate or seminal vesicles.

5. **Constipation**—is a common cause of backache. The pain is usually above the lumbar region and is constant, although variable in degree. A change of position may increase or decrease the pain.

6. **Rectal Diseases**—Proctitis, fistula, polyps, hemorrhoids, and rectal cancer may each cause backache in the sacral region.

7. **Gall Bladder Disease**—may cause a dorsal backache, usually associated with constipation. The pain is most commonly located in the middle and lower dorsal regions.

8. **Gastric or Duodenal Ulcer**—frequently manifests itself in the form of a dorsal backache, with occasional attacks of sharp, stabbing pain in the mid-dorsal region.

9. **Muscular Rheumatism**—particularly when it involves the Erector Spinae muscle. This condition is commonly known as lumbago. The pain is more marked after a period of rest, and the back becomes less painful after a period of exercise.

III. BACKACHE DUE TO INJURY

The Chiropractor probably encounters more cases of backache due to injury than any other type. Acute or chronic backaches associated with spinal trauma are seen in individuals in every walk of life and with histories of injury ranging from such a simple act as bending over, to a crushing blow on the spinal column. There may be injuries to the vertebrae, the intervertebral discs, the muscles, ligaments, or nerves. Injuries in the home may result from falls, overexertion, such as shoveling snow, or slips, twists, or strains.

Occupational or industrial backache frequently follows improper methods of lifting heavy objects, blows to the spinal region, assuming a cramped, distorted position over long periods of time, and fatigue from long working hours, or improper seating and lighting equipment.

Athletic injuries are very common. Games of physical contact such as football, basketball, and hockey are particularly guilty, although golf, tennis, and diving also come in for a large share of backache cases attributable to injuries.

The more common spinal injuries resulting in backache include the following:

1. **Fractures, Dislocations, and Fracture-Dislocations of the vertebrae.**
2. **Ruptured Intervertebral Discs.**
3. **Sacroiliac Joint Sprains.**
4. **Strains of the Spinal Muscles or Ligaments.**
5. **Vertebral Subluxations.**

IV. PSYCHOSOMATIC BACKACHE

The psychosomatic factor in the backache is a very real thing, and is a very common cause of pain in the spinal region. It is seen in those cases having a hypersensitive condition of the nerves, such as neurasthenia and hysteria. Some individuals suffering from neurasthenia have many symptoms; in others, the symptoms center upon some particular organ or region, and the spinal column is a frequent site of such concentration. It is said that neurasthenics experience a great variety of sensations around the spinal column, with an aching back being one of the outstanding features of this condition.

Extensive examination of the spinal column will not reveal any condition which might account for these aches or pains, excepting of course, the vertebral subluxation which brought on the neurasthenia in the first place. The spine is anatomically and functionally sound, but the mental processes are not faring as well in carrying out the balance between mind and body.

Chapter 18

NERVE INTERFERENCE

Chiropractic maintains that the cause of disease is nerve interference—that when a vertebra loses its proper relationship with the one above or the one below, or both, to the extent that it occludes a foramen, and interferes with the transmission of nerve impulses from brain cell to tissue cell, the result is disease. The correction of the existing factors in a vertebral subluxation is based upon the scientific application of an external concussion of forces, that is, an adjustment, which arouses an internal concussion of forces that in turn, corrects the cause of disease. Since its beginning the science of Chiropractic has been devoted to this simple premise. An adjustment given today, is for the purpose of correcting interference with the transmission of mental impulses, just as an adjustment given in 1895 was intended for the same purpose. That such nerve interference does exist, and that such corrective measures will restore health, is the key to Chiropractic. The test of time has but strengthened the soundness of the Chiropractic principle, with its phenomenal growth and general acceptance as a healing art.

The practitioner and the student of Chiropractic have come to regard the spinal column and the correction of nerve interference as the exclusive domain of the Chiropractic profession gained by prior rights and assumption. To continue thinking so is to be without vision and is a dangerous attitude. A rapidly increasing tendency on the part of research and therapy is to seek the cause of disease in the spinal column and to correct that cause by correcting nerve interference. The spinal column is being recognized as the seat of more abnormalities than any other part of the body structure, and is being held accountable for an increasing number of varied manifestations of disease.

At the present time, certain definite procedures have been developed to locate and correct nerve interference on the spinal

cord or spinal nerve roots. It might be well to briefly consider a few of these technics which are a part of the Chiropractic premise, if not the practice of Chiropractic as we know it.

(1) **Adhesions** around the nerve roots between their dural sheaths and the edges of the intervertebral foramina are known to cause nerve interference. The surgical correction is removal of these periradicular adhesions. Good results are claimed.

(2) **Osteophytic Protrusions** are ridge-like outgrowths of bony tissue from the edges of adjacent vertebral bodies. These ridges project into the neural canal and compress the spinal cord or spinal nerves. The surgical correction is directed toward removal of these hard bony ridges from in front of an adhering theca and spinal cord.

(3) **Ligamenta Flava Compression** of the spinal cord has been demonstrated in certain cases. This is held to be a cause of intermittent interference with the spinal cord, the pressure developing when the spine is extended and relieved when the spine is flexed. The mechanics involved is a bulging intraspinally of the ligamenta flava which has been weakened by previous injury or strain. The approach to this problem is either through permanent immobilization of the involved area, or removal of the offending ligament.

(4) **Rupture** of an intervertebral disc with backward protrusion causes a narrowing of the spinal canal and compression of the spinal cord or nerve roots. Definite acute or chronic degenerative changes consistent with nerve interference are demonstrable. In fact, a slow progressive protrusion of an intervertebral disc may gradually compress the spinal cord, giving the picture of an extradural tumor. The intervertebral disc frequently undergoes a degeneration which excites an osteophytic reaction in the bodies of adjacent vertebrae. The treatment is directed toward removal of the protruding disc which is causing nerve interference.

These are but a few of the ingenious approaches toward the removal of nerve interference. Besides surgery, other orthopedic techniques include immobilization with casts, traction, massage, and manipulation. It is this manipulation which is encroaching upon the art of Chiropractic. To all intents, manipulation and adjustment are synonymous as far as the ultimate objective is concerned—the correction of nerve interference.

Chiropractic maintains one great advantage over other healing arts in that it has long recognized the possibility of nerve interference existing without pronounced and gross changes in the alignment of the vertebral column. The vertebral subluxation seems a small thing to cause so much body disease, and yet, it is so. The searchers for the causes of nerve interference cannot, as yet, explain satisfactorily to themselves how a syndrome commonly associated with compression of the spinal cord or nerve roots is produced without apparent naked-eye compression of the nerve structures being visible at operation or post-mortem. The handwriting is on the wall. It seems but a matter of time until this orthopedic defect must become apparent and accepted as the cause of disease. The crude manipulations will be refined to the level of the highly specific and scientific Chiropractic adjustments. A package-deal of surgery, medicine, and Chiropractic will be difficult competition. It would seem that the future of Chiropractic orthopedy rests squarely upon each Chiropractor not only having a backbone, but upon intimately knowing the backbone in all its aspects, anatomic, physiologic, pathologic, and Chiropractic.